INDIAN TEA ASSOCIATION

SCIENTIFIC DEPARTMENT

TOCKLAI EXPERIMENTAL STATION

ANNUAL REPORT—1957

N S P
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COMMONWEALTH MYCOLOGICAL INSTITUTE
29 OCT 1958

INDIAN TEA ASSOCIATION

SCIENTIFIC DEPARTMENT

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ANNUAL REPORT—1957

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ANNUAL REPORT FOR 1957

DIRECTOR'S REPORT

H. FERGUSON—Director

A. D. SWAN—Scientific Officer

STAFF

During the year the following appointments were made: Mr. W. Hadfield was appointed as an Advisory Officer and joined the station on 22nd October. Dr. K. N. Sharma was appointed to a new post of Agronomist on 17th July, and Mr. N. C. Barua was appointed Maintenance Engineer on 1st June in place of Mr. B. M. Barua, whose temporary appointment expired on 31st May. Mr. D. J. Wood tendered his resignation from the post of Senior Biochemist in September.

The Director Mr. H. Ferguson was absent from the station on overseas leave from 24th May to 9th October. During this period Dr. Wight acted for the Director. Mr. P. M. Glover and Mr. M. J. Green were also on overseas leave during 1957. Mr. K. C. Sharma, Dr. P. C. Sharma, Mr. D. N. Borbora, and Mr. S. Basu had annual leave during the year.

During the year the following officers had local leave: Mr. Swan, Mr. Heath, Mr. Gokhale, Mr. Dutta, Dr. Wight, Dr. Barua, Mr Wood and Mr. Trinick.

Mr. Mitra took up the post as Assistant Advisory Officer, West Bengal on 8th April, Mr. Grice was posted to West Bengal as Advisory Officer on 18th November and for the remainder of the year acted for the Senior Advisory Officer, Mr. Macalpine, who was in Calcutta. Mr. Gray moved to the North Bank on 18th December and is initiating the North Bank Advisory Headquarters there.

Mr. Austin of Plant Protection Ltd. was seconded to the Station for a period of approximately six months from 2nd November to co-operate in field trials on control of tea flower diseases, red spider, eel-worm, and root and other diseases.

Dr. Roberts from the Association's Chemical Laboratory at Butler's Wharf visited the Station from 22nd November—12th December.

The Senior Staff at 31st December 1957 is listed below under Branches :

Directorate:

Director	H. Ferguson, B.Sc (Hons.)
Scientific Officer (H.Q.) ...	A. D. Swan, B.Sc. (St. A).
Personal Assistant to the Director	J. H. Blair.
Maintenance Engineer ...	N. C. Barua.

Physico-Chemical Branch :

Senior Physical Chemist ...	N. G. Gokhale, B.Sc. (Bom. & Lond.).

Botanical Branch :

Senior Botanist and Plant Physiologist ...	W. Wight, Ph.D. (Leeds).
Botanist & Selection Officer	M. J. Green, B.Sc. (Edin).
Plant Physiologist ...	D. N. Barua, Ph.D. (Cantab)

Agricultural Branch:

Senior Agriculturist ...	S. K. Dutta, B.Sc. (Bom. & Wales).
Asst. Agriculturist ...	S. K. Basu, B.Sc. Ag. (Delhi). Assoc. I.A.R.I.
Agronomist	K. N. Sharma, B.Sc. Ag., M.Sc. (Banaras), Ph.D. (Michigan) Assoc. I.A.R.I.

Plant Pathology Branch :

Senior Entomologist ...	G. M. Das, M.Sc. (Cal) D.I.C., Ph.D. (Lond).
Mycologist	K. C. Sharma.
Pesticide Testing Officer ...	Vacant.

Biochemical Branch :

Senior Biochemist ...	D. J. Wood, B.A. (Cantab)
Biochemist	N. B. Chanda, M.Sc., (Dac), Ph.D. (Edin).
Tea Taster	J. M. Trinick.

Engineering Development Branch:

Senior Research Engineer ...	I. McTear.
Asst. Research Engineer ...	D. N. Borbora, B.Sc. (Mining) (Banaras), M.Sc. (Engineering) (London) D.I.C.

Statistical Branch:

Senior Statistician ...	Vacant.

Assam Valley Advisory Branch:

Senior Advisory Officer, Assam	P. M. Glover, M.B.E., B.Sc.
Advisory Officer, Cachar ...	E. D. Heath, B Sc., Dip. Ag. (Cantab).
Advisory Officer, North Bank	D. J. Gray, B.A. (Cantab).
Advisory Officer (under training)	W. Hadfield, B.Sc. (Hons.).
Asst. Advisory Officer ...	P. C. Sharma, Ph.D., M.Sc., F.L.S. (Lond).

West Bengal Advisory Branch:

Senior Advisory Officer ...	R. I. Macalpine, B.Sc. (Forestry).
Advisory Officer ...	W. J. Grice, B.A. Dip. Ag. (Cantab)
Asst. Advisory Officer ...	H. Mitra, B.Sc.

VISITORS

The following members of the Indian Tea Association London Advisory Committee visited the station during the year under review :

Mr. A. N. Stuart, Chairman of the London Advisory Committee, Sir Percival Griffiths, London Adviser to the I.T.A.; Mr. E. J. Nicholls, Chairman of the Development Panel.

Other members of the I. T. A. London who visited Tocklai during the year were:

Sir James Jones of Messrs. James Finlay & Co., Ltd., Mr. K. Warren, of James Warren & Co., Ltd., London ; Mr. P. W. B. Pigot, Director, Dhoolie Tea Co., Ltd. ; Sir Henry Birkmyre and Mr. H Cockle, Directors, Andrew Yule Co., Ltd. ; Mr. R W. Carter, George White & Co. and Chairman of the London Tasting Panel; Mr. H. G. G. Mackay, Chairman, Jetinga Valley Tea Co., Ltd.

Members of the Indian Tea Association, Calcutta attended the Conference and are mentioned below in that connection. Mr. Atkins, Additional Adviser, Calcutta visited the station on two occasions during 1957.

In addition to the above many local Planters, Superintendents and Visiting Agents called to seek advice and discuss problems, and many visitors from Agency Houses and business concerns in India and the U.K. came to Tocklai in connection with matters associated with the tea industry.

Some of the distinguished visitors not associated with the Indian Tea Association are listed below in the chronological order of their visits:

Air Chief Marshall Sir Arthur Longmore, General Steedman and Brigadier Perry, of the Imperial War Graves Commission; Mrs. Dolaberidze, Mr. Chigogidze, Miss Koneva of the U.S.S.R. All Union Scientific Research Institute for Tea and Sub-Tropical Corps ; Mr. V. Vachhani, Director, Central Rice Research Station ; Mr. D. S. Burgess, Labour Attaché American Embassy ; Mrs.

Bracken, U.S. Vice-Consul and Mr. B. C. Cooper, U.S. Consul General; Professor M. S. C. Yakoklev, Deputy Director of the Botanical Institute of the University of Leningrad, Professor M. A. Bukuchava and Dr. V. R. Popov from Stalingrad University; C. Heureux, Office Des Produits Agricoles De Costermansville, Belgian Congo; Miss Adelaide Bornmann, Naugatuck Chemical International, New York; Mr. G. Brazendale, Trade Commissioner to the U.K. High Commission; Mr. D. M. Langton, Director of the Canadian Tea Council.

TOURING

The Director toured gardens in the Dooars and Terai in January, Cachar, in February, and Darjeeling in March. He also toured gardens in Upper Assam between 27th February and 2nd March and visited Nagajanka Tea Estate in November, in connection with Continuous Roller No. 1 (Rotorvane) which was under trial there. Calcutta was visited on several occasions in connection with Tea Board meetings and I.T.A. business.

MEETINGS

The Director attended the following Indian Tea Association meetings:

The Terai Planters Association Annual General Meeting on 23rd January; the Dooars Branch Indian Tea Association Annual General Meeting on 24th January; The Surma Valley Branch Indian Tea Association Annual General Meeting on 6th February; General Committee of the Assam Branch Indian Tea Association Annual General Meeting on 13th February; Annual General Meeting of the Indian Tea Association Calcutta on 8th March; The Darjeeling Branch Indian Tea Association Annual General Meeting on 16th March; the General Committee Meeting of the Assam Branch Indian Tea Association on 15th November; The Annual General Meeting of Assam Branch Indian Tea Association on 16th November; Quarterly meetings of the Scientific Department Sub-Committee were attended on 7th March, 31st May, 11th November

and 7th December. Zone II Assam Branch Indian Tea Association Committee Meetings and Jorhat Circle Committee meetings at Jorhat were attended from time to time throughout the year.

The Director also attended the following meetings not directly connected with the Indian Tea Association:

Assam Agricultural College Governing body on 17th January and 2nd November; Tea Syllabus Committee of the Assam Agricultural College on 15th and 16th February; Annual General Meeting of the Assam Tea Planters Association on 31st March; The Second meeting of the Agricultural Food Products Division of the Council of the Indian Standards Institute on 8th May. The Ross Institute Birth Centenary Celebration on 23rd November.

The following Tea Board Meetings were also attended by the Director:

Sub-Committee meetings of the Ad. Hoc Committee on Tea Research on 14th February and 22nd March; Sub-Committee meetings dealing with proposals for (*a*) Fundamental Research Station, (*b*) Fundamental Research on Entomology and Nematology, and (*c*) a Dooars Research Station on 3rd December; A Selection Committee meetings on 4th and 5th December; The 15th Meeting of the Tea Research Liaison Committee (Successor to the Ad. Hoc Committee on Tea Research) on the 5th December.

CONFERENCE

The 14th Annual Conference was held at Tocklai on the 12th, 13th and 14th November. The size of the Conference was considerably increased this year, a number of Agency House Representatives being invited to attend in addition to the delegates. The theme of the 1957 Conference was "Tea in Relation to Environment". Papers on this subject were delivered on the first day by Mr. Gokhale, Dr. Wight, Dr. Barua, Dr. Das, Mr. Sharma, Mr. Dutta and Mr. Wood. The papers were followed by brief discussions. On the second day papers

on the environmental problems of the main districts of North East India were read by Mr. Glover for Assam, Mr. Macalpine for Dooars, Terai and Darjeeling, and Mr. Heath for Cachar. Following each paper, delegates questions pertaining to the relevant district were answered and discussed. The third day of the Conference was reserved for demonstration and discussion of Engineering Development. This session was held in the Pilot Factory. On the afternoons of the first two days delegates visited Borbhetta, where the pruning/harvesting machine was again demonstrated, and toured the Tocklai laboratories. Minutes of the full conference proceedings have been distributed to all who attended, and circulated to Indian Tea Association Committee members.

In addition to the Tocklai staff the following attended the Conference:

Mr. C. D. Wilson, Chairman, I. T. A. Calcutta; Mr. N. S. Coldwell, Chairman, Scientific Sub-Committee; Mr. P. B. Nicholls, Mr. A. K. J. Henderson, Mr. E. H. Adams, Mr. J. E. Atkins, Mr. J. W. D. Kelly from the I.T.A. Calcutta; Mr. G. Hyatt, Mr. R. C. Reynolds, Mr. R. W. Gawthropp, Mr. J. D. Bruce, Mr. D. J. Simpson, Mr. J. E. Hall, Mr. D. F. Little, Mr. P. L. Achard as Branch delegates; Mr. R. G. Philipp, Mr. M. S. Christie, Mr. M. C. Whear, Mr. G. Butters, Mr. J. A. Morice, Mr. G. Carlton, Mr. J. H. Crabb, Mr. D. N. Pearson, Mr. A. Lawrie, Mr. H. J. Stevens, Mr. J. E. M. Turpin as Agency House representatives; and Mr. S. Ananda Rau, Mr. B. McNeill, Mr. N. K. Dutta, Mr. P. K. Barua, Dr. A. Gilroy, Mr. S. G. B. Brown, Dr. M. C. Das as distinguished guests.

Representatives of the Indian Tea Board and from Pakistan were unable to attend.

COURSES

Three general lecture courses each of 4 days duration were held between 18th February and 7th March. These were attended by a total of 81 Planters. These courses were run mainly by the Advisory Branch and covered the main aspects of

tea culture and manufacture. Two vegetative propagation courses each of 3 days duration, organised and run by the Agricultural Branch were held between 23rd and 29th May, and were attended by a total of 50 planters. 8 apprentices received training during the year.

PUBLICATIONS

The following Tea Encyclopaedia Serials, Journals and Articles were published by the Scientific Department during the year.

Tea Encyclopaedia Serials:

71/1 An addendum thereto, on Red Spider Control.

114 "Prevention and Control of Borers attacking Tea Chest Panels".

115 "N.P.K. Manuring of Tea Seed Nurseries".

116 "Uprooting of Tea".

117 "Vegetative Propagation".

118 "Vegetative Propagation Part I".

16/1 "Cleaning of Fermenting Floors".

21/1 "Seasonal Distribution of Yield in Assam Tea Estates"

36/2 "Hail Damage on Tea Estates".

40/2 "Crotalaria anagyroides."

43/2 "Infilling and Treatment of Infills".

53/2 "Medium Pruning."

59/2 "Green Cropping Programme for shading Tea Seed Nurseries".

65/2 "Branch Die-Back and Nectria".

68/1 "Branch Canker (*Poria hypobrunnea*, Petch) Following Sun-Scorch and Branch Damage".

100/1 "Fertilisers and Fertiliser Mixture".

Of the above the last ten were revised and reissued serials

Periodicals:

Annual Report of the Scientific Department for 1956.

"Two and a Bud" (Tocklai quarterly News Letter) Vol. IV Nos. 1, 2, 3 and 4.

"Cachar Quarterly" Vol. II, Nos. 1, 2, 3, & 4.

The "Cachar Quarterly" is produced by Advisory Officer, Cachar, and deals with topics which are of special interest to Cachar planters.

Articles and Scientific Papers:

"A New Record of a rare Fungus from Tea Rhizosphere", by V. Agnihothrudu & G.C.S. Barua—Science and Culture, April, 1957.

"What is Tea?" By W. Wight and P. K. Barua—Nature, March, 1957.

"Practical aspects of Spacing and Arrangement of Tea Plants in Commercial Tea Estates" By P. M. Glover —Tea & Rubber Mail, May, 1957.

"Assam Tea Looks Ahead" by W. Wight and N. G. Gokhale—*Amrita Bazar Patrika*—September, 1957.

LABOUR RELATIONS

The Tocklai Employees Union and the Jorhat Jilla Chah Mazdoor Sangha, both raised disputes during the year which were the subject of conciliation meetings before the District Labour Officer. The dispute raised by the Tocklai Employees Union eventually came up for further conciliation before the State Labour Commissioner in November, and, as no agreement could be reached, was referred to tribunal which is still pending. Since the conciliation meeting on the dispute raised by the Jorhat Jilla Chah Mazdoor Sangha, bilateral discussions have taken place and it is hoped a settlement may be reached. These two unions together with the Jorhat Chah Mazdoor Union, which represents Borbhetta labour, raised various other issues during the year most of which were satisfactorily settled by direct negotiations.

Day to day relationships between staff, employees, and labour have been satisfactory and cordial throughout the year.

LIBRARY

The new Librarian Mr. J. N. Sharma took over his duties on 16th January.

A new annexe to the Main office was completed in October and has been given over to the Library primarily for use as a stack room. Alterations to the old office have also allowed of a more spacious reading room, which it is hoped will be put into use early in 1958.

At the end of December the library contained 1,150 books, 72 having been added during the year. 1151 periodical, 717 pamphlets and bulletins and 1 map were received on a subscription or exchange basis from India, United Kingdom. United States, and from 17 other overseas countries.

The branch libraries at Cachar and Dooars were maintained and regularly supplied throughout the year.

GUEST HOUSE

The Guest House continued to function satisfactorily during the year ; but due to rising costs it was necessary to make slight increases in all rates. A total of 480 overnight guests (some staying for several nights) and 181 casual visitors used the Guest House during the year.

MEDICAL

The Medical Officer reports that 15,780 cases were treated during the year. The increase over previous years is partly accounted for by the increase in staff, partly by the more comprehensive application of the service, and partly by the incidence of Asian Influenza. In addition to this illness the following were common: Respiratory ailments, including bronchitis, pleurisy, pneumonia and plumonary tuberculosis ; Ear, nose and throat complaints ; Gastro-intestinal disorders ; Skin diseases, and eye disorders including conjunctivitis. The following surgical conditions were dealt with: tonsilectomy, apendicectomy, hysterectomy, fractures and dislocations. There were 76 accident cases which required anti-tetanus injections during the year.

Measles and whooping cough were common amongst children and one case of poliomylites also occurred.

Antimalarial measures at Tocklai and Borbhetta were continued throughout the year. Of 176 blood slides examined for malaria only one was positive. Several species of *Anopholes* were collected and identified. Control measures were mainly directed against *Anopholes minimus* in known breeding areas, but measures were also directed towards the control of all species.

Flies were again a major problem in the hot season of 1957. No available insecticide appears to have an appreciable effect. Finding an effective method of control has become a considerable problem.

BUILDING AND MAINTENANCE

Construction.— Most of the major construction work during the year was done by contract, but many of the minor items were carried out by the station maintenance staff. Work completed during the year included: construction of two staff quarters for the Engineering Department; extension and reorganisation of the main office block; car porches on bungalows 9, 10, & 14 and Borbhetta bungalow No. 1 & 2; three culverts under the approach roads to the Station on the East and a cattle trap on the approach road to the West; floors in the main office and the mycology laboratory were relaid, roof painting of seven bungalows and internal redecoration of bungalow and Guest House was completed; improvements to the Water supplies were made including the erection of overhead tanks and stagings at Borbhetta and at Bungalows 1 & 14 at Tocklai. Work still in progress at the end of the year included the construction of Bungalow 11 in replacement of that destroyed by fire earlier in the year; construction of twelve servants quarters; construction of a Miniature Factory; rewiring the main office, and clearing of new land.

Maintenance.— Running repairs as necessary were carried out on all roads, buildings and fencing etc.

Machinery and Equipment.— A new 55 K.W. alternator was purchased and installed in the Main Power House at Tocklai. The 27 K.W. Generator was removed to an annexe of the Pilot Factory and will be used primarily to power the

machinery there, thus reducing the strain on the main Power House.

Transport.— The Land Rover was derequisitioned by the Government in August, but required extensive repairs.

RESEARCH AND EXPERIMENT

Detailed reports of research and experiment carried out by each branch and section of Tocklai form the main part of this Annual Report, but brief summaries of the more important aspects of these are given here.

Physico-Chemistry and Meteorology.— Investigations have been continued on the long term effects of manurial treatments on the nitrogen status of Borbhetta Soils under tea, and the current results of some of these investigations are given. Leaf analysis studies were started during 1957, the objects being to study the potash/phosphate status of the tea plant and its relationships to prolonged manurial treatment, and to study the effect of continuous sulphate of ammonia treatment on the calcium and magnesium status of leaf composition. Data are being accumulated and it is hoped that this may lead to a method of diagnosing manurial requirements by leaf analysis. A study was made of the phosphate uptake of the green crop *Crotalaria anagyroides* in a P.K. and Ca. manurial experiment. Even under the acid conditions of Borbhetta soils there was more than 10% recovery. This was not increased by Ca. application. Estimation of the chlorine uptake of tea under the application of ammonium chloride and ammonium sulphate was continued. The branch continued to be responsible for meteorological observations which have now been extended to Advisory Sub-stations. Those from Silcoorie which started functioning in 1956 are recorded in this report. As far as time permitted statistical investigations in accumulated meteorological data have been carried out.

Botany.— The work of this branch covers the physiology, morphology, breeding and systematics of the tea plant and their relationship to the cultural problems of the crop. The current report records progress in the systematics of tea, in the prac-

tical applications of the phloem index, and in the development and testing of biclonal progenies. Studies on the relationship between green weights and dry weights of tea produced under shaded and unshaded conditions have established that any single conversion factor is subject to error, and further data on the relationship between shade and manure are given. Experiments have indicated the possible value of the yield of young tea as a reliable indication of the yield of mature bushes; and the value of unit weight (*i.e.* the ratio of the weight of prunings to the phloem index) as a pre-estimate of experimental yield differences has been demonstrated. This latter is the subject of a detailed self contained note given as an appendix to the report. Similar notes on "Selection Policy in Tea Estates of North East India" and on the "Nature of the Plucked Tea Shoot conditioned by Shade and Manure" are also appended to the report.

Agriculture.— Approximately 50 field experiments were in progress during 1957. These were predominantly concerned with Manuring, Shade, Pruning and Plucking. Most of these experiments are long term, and it is unnecessary to report on each one every year. Only some of these which have reached the stage of yielding useful information have been dealt with, and the current report has concentrated mainly on long term manurial trials. Nitrogen has continued to give significantly higher yields in mature tea, but P and K have been found beneficial to young tea only. A noteworthy result is that responses to urea have fallen off compared with sulphate of ammonia over the last six years. A short term experiment has established the benefit of organic manure at the time of planting young tea, and the advantages of "bheti" planting in establishment. Experiments with shade trees, green crops and other ancillary crops have been continued. A green crop manuring experiment has established the value of phosphate for *Crotalaria anagyroides*. In a bamboo manuring experiment a response has been obtained to N.P.

Plant Pathology—Entomology.—While much of the time in 1957 was again taken up with trials of insecticides and acaricides it was possible to devote more time than in the previous year

to studies of the actual pests. Preliminary investigations into the life histories of Pink mite, Flushworm and Jassids and some of their parasities were undertaken, and studies of the relationship between Coccids and Ants were continued. Observations of the degree of incidence of various pests on shade and on the susceptibility of different clones to Red Spider and Jassid attack were also carried out. Field trials with new acaricides and insecticides were continued. Routine eelworm counting was continued and limited experiments and investigations on eelworm were conducted.

Plant Pathology—Mycology.— Testing of fungicides continued during 1957 and successful results were obtained with certain copper fungicides against Red Rust and Black Rot, but prolonged and thorough trials of Crag Fungicide No. 974 have shown it to be ineffective against the commoner root diseases. Further enlarged trials with Fernide against tea flower diseases were started in co-operation with Messrs. Plant Protection and the Assam Advisory Branch. Much of the basic research work of this branch during 1957 was concerned with investigation into the biology of tea flower *Botrytis*. Special studies were made of this and the other fungi isolated from tea flowers. These investigations are reported in detail in the current report for the purpose of putting them on record, the main results being given in an appendix to the report entitled "Symptomatology and Etiology of Tea Flower Disease". As usual, a large number of specimens were identified for advisory purposes, and further information on the occurrence and distribution of diseases was accumulated.

Pesticide Testing Unit.— The setting up of a unit to test the efficacy of commercial pesticides against tea pests and diseases was approved in 1956, but only the preliminaries were possible in 1957.

Biochemistry.— Fundamental work on the "Chemical Basis of Quality", which was started in 1956, continued in 1957. Taster's report and chemical analysis of tea made from nine different sources have been compared with a view to relating liquor characters with chemical composition. Work on the chemical differentiations of forms of tea and other *Camellia*

species was carried out by paper chromatography. It was found that certain chemical substances are associated with China, Assam and Southern forms of tea, and the presence or intensity of the corresponding chromatogram spots is closely related to the known or adjudged botanical origin of a tea. Investigation of the volatile constituents of tea continued with a view to finding out how much these contribute to quality. The Darjeeling character experiment was continued, in which separate manufacture of "China" and "Assam" kinds of tea from Darjeeling were compared with a view to determining if Darjeeling flavour is related to kind of tea. This season's results clearly indicated the superiority of China types in contributing to Darjeeling character, but chemical examination of the samples indicated that teas of different origin probably also play a part. Manufacturing experiments were also continued in 1957. These included an investigation into the standard of plucking best suited to Legg-cut manufacture, which indicated that leaf plucked at seven day intervals produced more valuable Legg-cut tea than that plucked at longer intervals.

Tea Tasting.— Nearly 8,000 samples were tasted during the season. These consisted of Tocklai experimental samples and clones, and factory experimental teas from commercial gardens.

Engineering Development.— Investigations and experimentation on mechanical harvesting and pruning has been continued. These have resulted in further improvements in performance, and have indicated interactions between the machine and the crop. The two continuous rolling machines have undergone further development and machine No.1 (Rotorvane) has been subjected to continuous trials in a commercial factory. Investigations into withering at high spreading density indicated that successful withers could be obtained in the Tocklai tunnel with spreads up to 8 lbs. per sq. yard. At the end of the year the continuous withering machine designed and fabricated in the U.K. was received, and is being installed in preparation for trials in the coming season. A prototype continuous drier, working on the same continuous principle as the withering machine, is being developed. Data was obtained on the generation of heat during fermentation with a view to controlling and mechanising the process.

Statistics.— A preliminary programme for the new statistical unit was prepared, with the main object of exploring possible approaches for various surveys. In the absence of a statistician no start could be made on this programme.

ADVISORY SERVICES

The two advisory officers (Mr. Gray and Mr. Grice) who joined the service in 1956 completed their training at Tocklai. It was therefore possible towards the end of the year to make a start with the establishment of a North Bank (Assam) Advisory Branch and Mr. Gray was posted to this area in October to open the new Station. An Assistant Advisory Officer was posted to West Bengal in the early part of the year, his main duties being to visit non-member gardens. Later in the year the Advisory Officer, Darjeeling (Mr. Grice) was posted to West Bengal. Due to the unavoidable absence of the Senior Advisory Officer, however, he also acted in the Dooars. In October a new Advisory Officer (Mr. Hadfield) joined the Station and is at present under training. The advisory services have therefore now been brought up to full establishment. By the end of 1957 advisory officers were allocated as indicated in last years report, but the full benefit of these allocations was not felt in 1957.

Assam Advisory Branch—Assam (Brahmaputra) Valley.— In the Assam Valley (North & South Bank of the Brahmaputra) 160 gardens in all were visited in 1957. This total includes 42 gardens in the North Bank visited prior to the opening of the North Bank advisory unit at the end of the year and 23 gardens which were not members of the Indian Tea Association, Calcutta. As usual much advisory work was carried out by means of correspondence, lectures and demonstrations. The programme of field experiments in tea gardens was continued, and a special series of pest control experiments was started towards the end of the year in co-operation with Messrs. Plant Protection Ltd. and the Plant Pathology Branch at Tocklai.

Assam Advisory Branch—North Bank.—The opening of this branch is briefly reported in the current report.

Assam Advisory Branch—Cachar.— Visits to 88 gardens in Cachar district were made in 1957. This total included 8 gardens not members of the I.T.A., Calcutta. The programme of experiments in tea gardens in Cachar district was continued in co-operation with the gardens concerned and the Agricultural Branch. Certain short term investigations carried out by Advisory Officer are also reported.

West Bengal Advisory Branch.— As the Dooars and Darjeeling and the Terai continued to be run as a single unit in 1957 the current report refers to both areas. A total of 162 gardens were visited in West Bengal. This total includes 16 gardens not members of I.T.A., Calcutta and some gardens visited for advisory purposes by members of Tocklai staff. Experiments on manuring, pruning cultivation and shade trees were carried out in tea gardens in different parts of the Dooars and Darjeeling in co-operation with the managers concerned and the Tocklai Agricultural Branch. The progress of these experiments is reported in the current report.

BUTLER'S WHARF LABORATORY

For the second year we include in this report a resume of the investigations being conducted into the chemistry of made tea, at the Association Butler's Wharf Laboratory in London. There is close liaison between the London laboratory and Tocklai, and this was further promoted by Dr. Robert's visit to Tocklai in November, 1957. It will be seen from this report that work complementary to that done at Tocklai on the chemical differentiation of species has been carried out in close co-operation with the Botanical and Biochemical branches at Tocklai. Further work has been done on the isolation and composition of the chemical compounds of tea, particularly theaflavins and thearubigins. These studies have led to development of practical tests which give a measure of certain commercial attributes of tea. Interesting comparisons in this respect between orthodox and C.T.C. manufacture and between seasonal differences have been demonstrated. Extensions of the work on the chemistry of fermentation are also reported.

PHYSICO–CHEMICAL BRANCH

N. G. GOKHALE—Senior Physical Chemist

STAFF

The Agricultural Chemistry unit which was formerly attached to the Agricultural Branch has been transferred to the Physico-Chemical Branch with effect from 1-1-57. Messrs. Majumdar and Mukhia, meteorological assistants from the Advisory Branches, were trained as meteorological observers.

RESEARCH AND EXPERIMENT

Nitrogen status of the top soil under continuous cropping and with manuring, in the case of unshaded tea (Borbhetta area 43):

In all the data quoted by Mann[1] and our previous work[2] on the subject of soil nitrogen losses under continuous cropping, the areas sampled were always adjacent but, of course, it had to be assumed that they were initially comparable. Data from Borbhetta area 43, where soil samples have been drawn from the identical plots at varying times, are now presented briefly. It is unfortunate that soil data for the different plots before the experiment commenced in 1930, are not available. The Data for January 1937 have been quoted by Cooper[3]. For the February 1940 data (unpublished work), we are indebted to Dr. D. N. Barua, Plant Physiologist, Tocklai. Samples were drawn by us from the identical plots in February 1956. In all cases, the data refer to only the top 9″ of the soil. At this stage, it must be stressed that the tea in Borbhetta area 43 is now 36 years old, has never been infilled, and has remained

References:

(1) Mann, H. H.: (1907), "The tea soils of N. E. India and their treatment", Indian Tea Association, Calcutta, pp. 66–67

(2) Tocklai Expt. Station, Physico-chemical Branch, Report for 1st Quarter 1953, p. 27

(3) Cooper, H. R.: (1946), "Nitrogen supply to tea", Indian Tea Association, Tocklai Expt. Station, memorandum No. 6 revised third edition, p. 146.

unshaded throughout this period. The yields were, however, steadily increasing until about 10 years ago and, even in 1956, although the yield of the continuously unmanured plots had dropped to 5.10 mds./acre, the corresponding figure with 80:40:40 manuring (split application, March and July) was 12.16 mds./acre, which is a reasonable yield for unshaded tea under these conditions.

Description of Borbhetta area 43.—Jat of tea is Dark Mesai Manipuri, planted 1922, $4\frac{1}{2}$ ft. tringular, unshaded. The manurial trial commenced in 1930. Initially, the treatments were 0, 40:20:20, 80:40:40 and 120:60:60 (shown as lb. of N, P_2O_5 and K_2O respectively per acre), the manure being applied both in single (in March) and divided doses (between March and July). In 1940, there was a slight rearrangement, treatments 160:80:80 (single and divided) and 200:100:100 (single) having been substituted for three of the previous treatments. The statistical lay-out is randomised with each treatment repeated in the seven blocks.

Full results of this investigation will be published elsewhere but a pictorial representation of the data is given in figure 1. The deterioration with time in the soil nitrogen status can be seen easily, but the pronounced effect of manuring should be noted carefully. The change with time is expected to be exponential on theoretical grounds, and an approximate solution for the data is given by

$$Y = 0.117 - B(1 - e^{-0.09\ t})$$

where t is the time in years (from 1930) and the constant B varies with the rate of manuring. A multiple correlation test shows the fit to be good. It may be specially mentioned that the calculated effect of manuring on the soil nitrogen status is roughly proportional to the rate employed.

It is suggested that the constant 0.09, shown above, is a characteristic index for the particular set of soil/climatic conditions concerned, although its value may be modified slightly

depending upon the mode of manuring (for one other such index see [4]).

Additional support for the above solution is available from one of the treatment series which was altered in 1940. In this case, manuring was increased from 80:40:40 to 160:80:80 (both applied as split doses in March and July). There should be some increase in the soil nitrogen on this account, although the deterioration with time will be as before. The calculated loss under these conditions worked out to 0.003, as against an actual drop of 0.004 between 1940 and 1956.

The above results show that in the case of unmanured and unshaded tea, and when no infilling is done, the nitrogen status of the top soil can ultimately drop by as much as 41% of its original value. The loss is proportionately lower with manuring but it is still 27% at the 120:60:60 manurial rate. Admittedly, the case quoted here is an extreme one and the results are, of course, not meant to be applicable for shaded tea. It is now standard practice in N. E. India to grow tea under shade but there are, nevertheless, large areas of tea where the shade is poor, or even non-existant, on account of the difficulties of establishing shade. Our findings may have some bearing in their case. Similar data for shaded tea will be collected as and when possible.

Effect of single vs. divided application of fertiliser on the nitrogen status of the top soil, in the case of unshaded tea (Borbhetta area 43):

Data have already been published (*see* pages 129-132 of reference 3) about the yields obtained when fertiliser is applied in single *vs.* divided doses (at various times). Data are now presented about the soil nitrogen status of the same Borbhetta area for which Cooper quoted yields. A brief description of the experiment has already been given. It is unfortunate that full details of the 1937 soil data recorded by Cooper cannot be traced. The 1940 data, however, serve to show the position at the end of 10 years continuous treatment. Analysis of this shows that the treatment effect of Single *vs.* Divided doses of

(4) Gokhale, N. G. : (1955), Emp. J. Exp. Agri., **23**, p. 98.

fertiliser is statistically significant. The mean values are given (for the plots concerned on the rearranged basis) in table 1.

Table 1 : Mean values of soil nitrogen (top 9"), % on dry weight, data for 1940 and 1956, Borbhetta area 43, unshaded tea.

Method of fertiliser application	In 1940	In 1956	Diff. between 1940 and 1956
Single dose in March ...	0.092	0.082	0.010
Divided doses (March/July) ...	.096	.088	.008
Divided dose application better by ...	.004	.006	

A more precise proof is obtained by a statistical comparison of the data for 1940 and 1956. A summary of the analysis of covariance for the combined data is given in table 2 and provides statistical proof that soil nitrogen status is better when the fertiliser is applied in divided doses.

Table 2 : Summary of the analysis of covariance of the 1940 and 1956 data for the top soil, Borbhetta area 43, unshaded tea.

Source	Adjusted values			
	D.F.	S.S. $\times 10^6$	M.S. $\times 10^6$	F
Treatment	9	1,587	176	2·08*
Check vs. Manure ...	1	721	721	8·52**
Single vs. Divided (a) ...	1	418	418	4·94*
Dose of manure (b) ...	3	438	146	
Interaction (a × b) ...	3	331	110	
Highest single vs Single & divided ...	1	5	5	
Error	53	4,486	84	

(Note : * and ** signify statistical significance at $P < 5\%$ and 1%, respectively)

It is clarified that, in presenting the above results, no immediate practical application is implied at this stage. When deciding manuring policies, the criteria of probable effect on the tea bushes, cost of application and availability of labour, must continue to be used by the planter.

The long term effects of N.P.K. manuring on the nitrogen status of 3 ft. soil profile, in the case of unshaded tea (Borbhetta area 43):

Data recorded in the past in soil nitrogen studies are mainly in respect of the top 9″ of the soil. We have decided that in all our studies on this subject, observations will be recorded about the soil profile to a minimum depth of 3 ft. Data are now presented about the changes brought about in the soil profile at the end of 26 years continuous manurial treatment in Borbhetta area 43, details of which have already been given above. Soil samples from four depths (0″—9″, 9″—18″, 18″—27″ and 27″—36″) were drawn from all plots in February 1956. Statistical analysis of the data shows that the treatment effects with Dose of Manuring and also the (depth × Dose of Manuring) interaction are significant at $P < 5\%$ and $P < 0.1\%$, respectively. Details are not presented here but a summary of the information for the four depths is given in table 3.

Table 3 : Statistical significance of the differences in the soil nitrogen values, when compared to unmanured plots, Borbhetta area 43, unshaded tea, data for 1956.

Manurial treatment since 1940	Soil depth			
	0″ – 9″	9″ – 18″	18″ – 27″	27″ – 36″
40 : 20 : 20	+ +		– –	– – –
80 : 40 : 40	+ +			–
120 : 60 : 60	+ + +	+		–
160 : 80 : 80 (C)	+ + +	+ + +		
200 : 100 : 100 (C)	+ + +			

(Note 1 : The symbols +, + +, + + + and also –, – –, – – – signify that the differences in the soil nitrogen values, compared to that for the corresponding unmanured plots, are statistically significant at $p < 5\%$, 1% and O. 1%, respectively. The positive and negative symbols are used to show whether the particular value is either higher or lower than the corresponding value for the unmanured plot).

(Note 2 : (C) refers to the fact that in the case of treatments 160 : 80 : 80 and 200 : 100 : 100, the treatments were 80 : 40 : 40 : and 120 : 60 : 60, respectively, until 1939).

The progressive beneficial effect of manuring on the top 9″ of the soil is seen clearly. This is also seen to a lesser extent for the second depth. The data also show that at the lower rate of manuring, the sub-soil is actually worse off compared to the unmanured plots, starting from the lowest depth upwards.

The total amounts of nitrogen contained in the soil profile with varying rates of manuring were calculated and the data are presented in table 4.

Table 4 : Total amount of nitrogen in soil profile with varying rates of manuring, Borbhetta area 43, unshaded tea, data for 1956 (i.e., at the end of 26 years treatment).

Manurial treatment since 1940	lb. of nitrogen per acre in 3ft profile	Remarks
Check (no manure)	7,889	
40 : 20: 20	7,623	
80 : 40 : 40	8,099	
120 : 60 : 60	8,288	
160 : 80 : 80(C)	8,509	*diff. sig. P < 5%
200 : 100 : 100(C)	8,321	
Least significant difference at P = 5% for comparison with unmanured plots	592	

The nett effects in the case of the first four treatments in table 4 are the results at the end of 26 years continuous fertiliser treatment at unchanged rates. In the case of the remaining treatments, fertiliser application was increased from 1940 onwards by 80 : 40 : 40, in each case, from the previous levels. The 1956 result in their case is therefore the nett effect of the original treatment for 10 years and the increased rates for 16 years. There is an indication in these results, that while high rates of manuring undoubtedly improve the soil nitrogen status, the long term effect of manuring at very low rates may be to leave the soil poorer than even unmanured areas. Further investigation is necessary before the full significance of these results becomes clear.

Recovery of applied superphosphate by green crop on an acid tea soil (Borbhetta area 103):

An attempt was made to assess the percentage recovery of applied superphosphate in the case of our acid tea soil, the pH (of water extract) value for which is about 4.7.

Description of Borbhetta area 103.—This is an experiment to study the effect of phosphate, potash and calcium manuring at different rates and in combinations, on the growth of *Crotalaria anagyroides*. Manuring was at three levels (0, 40 and 80 lb. per acre) of P_2O_5 and K_2O applied in the form of superphosphate and sulphate of potash, respectively, and two levels (0 and 4 mds. per acre) of slaked lime. The statistical design is in randomised blocks with three replicates. The green crop was planted at the end of April 1957, in rows $2\frac{1}{2}$ ft. apart, and the plants were thinned out at 6″ spacing when 6″ high. The manures were applied before sowing. The green crop was lopped by the end of July 1957, the loppings being returned to the soil in their respective plots.

Representative samples, three plants from each plot, were drawn on the 24th July 1957, immediately before the lopping was carried out. A further series of samples were collected on the 25th November 1957, when the plants were at the flowering stage. The plants were analysed for their total P_2O_5 content, using a standard colorimetric method employing stannous chloride as the reducing agent.

Full results of the investigation will be published elsewhere but are summarised here briefly. A pictorial representation is given in figure 2. The uptake of phosphate with dose of phosphate applied is linear in both cases, the regression co-efficients being statistically significant at $P < 5\%$. The percentage recovery is calculated to be approximately 10% and 14% at the end of 3 and 7 months, respectively. The latter figure is not, strictly speaking, the recovery of the applied inorganic phosphate but really the nett effect of 90% in the form of inorganic phosphate and 10% in the form of loppings. This does not, however, detract from the value of the results, since from the practical point of view, one is interested only in the nett amounts of phosphate which can be recovered. Our figures compare favourably with the data recorded in the U.K., for which

FIGURE 1

NITROGEN STATUS OF THE TOP SOIL (9") UNDER CONTINUOUS CROPPING AND MANURING IN THE CASE OF UNSHADED TEA—BORBHETTA AREA 43

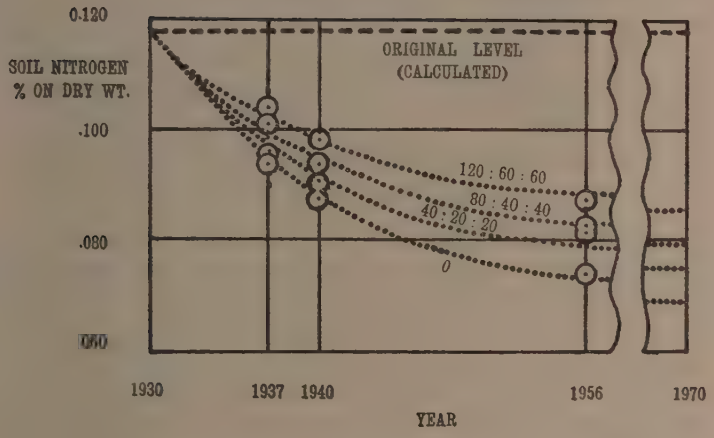
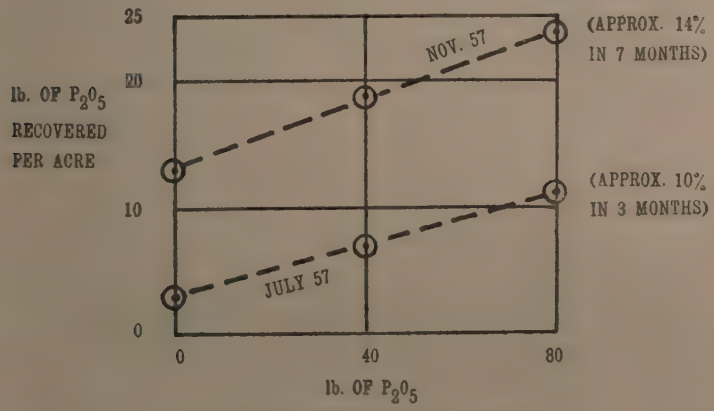


FIGURE 2

RECOVERY OF APPLIED SUPERPHOSPHATE ON AN ACID TEA SOIL, BY GREEN CROP—BORBHETTA AREA 103

(PERCENTAGE RECOVERY FIGURES SHOWN IN BRACKET)



Russell[5] states that "in normal British farming practice, it is unlikely that more than 10 per cent is recovered in the crop to which the fertiliser is given and a further 10 per cent in the succeeding crops".

Chlorine uptake by the tea plant with application of Ammonium chloride (Borbhetta area 28):

This investigation continues from the previous year[6]. The chlorine content of the "second leaf" sample reached about 0.1% on dry weight, immediately after application of the fertiliser in 1957, but ultimately fell to the same value as in 1956, by the end of the season. Further observations will be recorded on these plots.

Effect of prolonged Ammonium Sulphate treatment on the calcium status of tea leaf (Borbhetta areas 5, 7 and 45/47):

Certain information about the effects of prolonged Ammonium Sulphate treatment on soil properties has already been published[7]. Data have now been collected about the calcium content of the "second leaf" samples from the same plots. Samples were collected on three occasions during 1957 from all the plots. The mean calcium content with different doses of Ammonium Sulphate applied in the case of Borbhetta area 5, are presented in table 5. Statistical analysis shows that calcium content is significantly decreased ($P < 1\%$) with ammonium Sulphate treatment.

Table 5: Calcium content (Ca), % on dry weight, of the "second leaf", with prolonged Ammonium Sulphate treatment, Borbhetta area 5, mean for shaded and unshaded plots.

Amounts of Nitrogen applied (in the form of Ammonium Sulphate), lb. per acre		Calcium content of second leaf, 1957
per annum	total since the experiment started	
0	0	0·457
30	450	·449
60	900	·434
90	1,350	·429
	L. S. D. 5%	·014
	L. S. D. 1%	·019

(5) Russell, Sir John: (1950), "Soil conditions and plant growth" 8th Edition revised by Russell, E. W., London, Longmans Green, p. 455
(6) Indian Tea Association, Scientific Dept., (1956), Annual Report p. 25
(7) Indian Tea Association, Scientific Dept., (1955, 1956), Annual Reports, pp. 21-26 and 16-20, respectively.

Similar results were obtained in the cases of Borbhetta areas 7 and 45/47. The results also show that there is marked seasonal variation in the calcium status and different jats may be expected to have different values. More information will be necessary before it is possible to interpret these results. It is, however, stated that a watch is being kept on the various effects of prolonged Ammonium Sulphate treatment on leaf composition and, in addition to the calcium data quoted above, attention is also being paid to the magnesium and potash status of the leaf.

Leaf analysis for N.P.K. field trials (Borbhetta area 7 and Sephinjuribheel tea estate):

The immediate object of this investigation is to collect data about the phosphate and potash status of the tea plants from various N.P.K. field trials now in progress: the ultimate object will be to attempt to diagnose manurial requirements of tea from leaf analysis. The most direct way of answering this latter question is, of course, by carrying out actual field trials. The impracticability of carrying out a trial for each and every set of conditions, the long period for which the trial has to continue and other difficulties, however, necessitate that at least attempts be made to obtain the information by other methods, although it should be self-evident that the latter are no substitutes for field trials. Among these methods, we have decided to experiment with soil and leaf analysis, especially the latter, in view of the special complications of the manuring problem in tea. The difficulties of interpreting results of leaf analysis should be fully understood. Leaf composition is known to vary with physiological age, time of the day and season and, finally with the kind of tea grown, for a given set of soil climatic conditions, and the results may vary widely in different locations.

During 1957, samples were collected from the N.P.K. field trial in Borbhetta area 7 and the Sephinjuribheel field trial (we are grateful to the General Manager of the estate for his co-operation). These two trials were chosen because, unlike other trials, both of them have exhibited a marked response to P and/or K manuring in the case of mature tea. The "second leaf"

samples were analysed for potash and phosphate content and considerable data have been collected. The investigation will be continued.

Statistical studies in climatology :

A number of investigations have been undertaken, full results of which will be published in due course in the technical press. Amongst this work, special mention should be made of our studies into the fine pattern and structure of rainfall. The importance of rainfall distribution for tea need hardly be stressed.

(*a*) *Frequency distributions of rainy days by categories of daily rain.*—The data for Tocklai have been examined. Similar data for selected stations in N. E. India are now being examined.

(*b*) *Statistical studies of wet and dry spells.*—The data for Tocklai have been examined and it is seen that the spells show definite "persistency". The data from certain other stations are under examination.

PUBLICATIONS

Two technical communications have been accepted for publication, one each by the "Emp. J. Exp. Agriculture" and "Nature". One other paper is awaiting publication.

ADVISORY

Touring.— During the year, the Senior Physical Chemist paid visits to 23 tea gardens in the Eastern Dooars, Cachar and the Assam Valley (Bishnauth, Tezpur, Borsola and Sonari circles) to investigate soil problems. In addition, he attended a meeting of the I.C.A.R. in New Delhi to discuss fertiliser supplies for tea, and the Indian Science Congress session in Calcutta.

Routine analytical work.— A total of 1,055 soil and other samples were analysed during the year. The soil samples examined were mainly in connection with selection of nursery sites,

and areas due for uprooting/replanting of tea. A survey was carried out of the iron content of water from Cachar tea gardens (joint investigation with the Tea Taster).

Correspondence.— During the year 345 advisory reports were issued to tea gardens and in addition, 355 other letters were written.

METEOROLOGICAL OBSERVATIONS

Tocklai Station Meteorological Observations 1957: (Tables 6 to 9)

Table 6

Month	Mean temp. °F		Sunshine in hrs.	Rainfall in inches	No. of rainy days.	Terrestrial min. temp. °F.
	Max.	Min.				
January ...	70·9 (71·9)	49·9 (48·4)	4·9 (5·6)	1·55 (0·89)	4 (5)	45·2 (44·4)
February ...	72·5 (75·2)	54·1 (53·0)	5·1 (6·1)	2·14 (1·28)	12 (8)	48·1 (46·1)
March ...	83·1 (81·2)	58·5 (59·6)	8·4 (6·6)	0·80 (3·53)	6 (11)	51·6 (53·1)
April ...	84·1 (83·3)	64·6 (65·7)	7·4 (5·8)	6·74 (7·74)	18 (17)	56 ·7 (59·2)
May ...	82·9 (85·9)	70·0 (70·9)	5·7 (5·0)	26·88 (11·06)	27 (20)	64·8 (67·8)
June ...	89·0 (88·9)	76·0 (75·1)	5·4 (4·5)	14·68 (12·78)	21 (23)	74·3 (73·9)
July ...	90·8 (90·0)	77·3 (75·9)	4·5 (4·9)	17·02 (15·13)	24 (25)	76·2 (74·8)
August ...	90·3 (89·8)	77·3 (75·8)	5·7 (5·2)	12·45 (13·02)	21 (23)	75·3 (73·6)
September ...	89·5 (88·2)	76·2 (74·5)	5·8 (4·9)	6·94 (10·33)	15 (19)	74·8 (72·4)
October ...	84·5 (84·6)	68·6 (69·3)	6·9 (5·4)	4·98 (4·71)	13 (12)	65·7 (68·9)
November ...	80·6 (79·1)	61·2 (58·9)	6·5 (5·8)	2·06 (1·11)	5 (4)	57·1 (55·8)
December ...	74·1 (73·6)	53·4 (50·7)	6·3 (5·7)	0·71 (0·44)	4 (3)	49·0 (45·3)
Total ...				96·95 (82·02)	170 (170)	
Average ...	82·7 (82·6)	65·6 (64·8)	6·0 (5·5)			61·6 (61·3)

NOTE :– Data in brackets show previous averages.

Table 7: % Relative Humidity, monthly averages

Hrs. I. S. T.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
06 13	98 (97)	97 (95)	93 (94)	91 (92)	95 (93)	93 (92)	95 (94)	94 (95)	95 (95)	96 (97)	97 (98)	98 (98)
13 13	63 (61)	63 (57)	45 (60)	60 (66)	76 (71)	76 (75)	74 (75)	74 (76)	72 (75)	68 (74)	65 (67)	63 (64)

Table 8: Vapour tension, monthly averages, in inches of mercury

Hrs. I. S. T.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
06 13	0.398 (.388)	0.434 (.417)	0.507 (.522)	0.618 (.643)	0.748 (.794)	0.900 (.886)	0.928 (.911)	0.930 (.919)	0.900 (.903)	0.714 (.759)	0.557 (.557)	0.415 (.396)
13 13	0.453 (.450)	0.451 (.486)	0.482 (.579)	0.636 (.705)	0.787 (.813)	0.922 (.922)	0.971 (.951)	0.971 (.971)	0.930 (.947)	0.747 (824)	0.623 (.639)	0.498 (.500)

NOTE :—Data in brackets show previous averages.

Table 9: Soil temperature °F., % soil moisture and evaporation from U.S.A. open pan Evaporimeter and Piche Evaporimeter, monthly averages.

Month	Soil temp. in BARE plot, at depth						Soil temp. in GRASS plot, at depth						% soil moisture (top 9")		Evaporation in inches (daily mean)	
	at 0613 hrs. I.S.T.			at 1313 hrs. I.S.T.,			at 0613 hrs. I.S.T.			at 1313 hrs. I.S.T.						
	5 cms	15 cms	30 cms	5 cms	15 cms	30 cms	5 cms	15 cms	30 cms	5 cms	15 cms	30 cms	morning	afternoon	USA open pan (1)	Piche (2)
January ...	56·6	60·6	65·2	72·0	66·1	65·1	?	?	?	?	?	?	15·2	15·1	0·047	0·052
February ...	58·8	62·3	66·2	73·8	67·9	66·0	?	?	?	?	?	?	16·1	16·1	0·070	0·075
March ...	66·1	70·4	74·1	88·5	78·6	73·9	?	?	?	?	?	?	12·6	12·0	0·134	0·153
April ...	71·0	74·6	78·1	90·3	82·7	78·2	72·8	75·9	77·8	87·6	80·3	77·9	13·6	13·3	0·163	0·127
May ...	75·0	77·2	79·6	90·2	83·5	79·7	77·3	79·0	80·1	86·3	81·5	80·2	18·9	18·5	0·193	0·075
June ...	80·1	81·6	83·6	93·6	88·2	84·2	83·1	84·3	84·6	90·1	86·0	84·6	18·9	18·7	0·150	0·078
July ...	81·0	83·2	85·8	95·3	89·3	86·0	84·5	86·1	86·7	91·2	87·6	86·7	19·9	19·3	0·165	0·075
August ...	81·1	83·3	85·8	95·7	89·5	86·0	84·6	86·1	86·8	91 6	87·7	86·8	19·1	18·9	0·154	0·081
September ...	79·7	82·0	85·1	94·8	89·0	85·4	83·4	85·3	86 4	91·7	87·8	86·6	18·1	17·6	0·134	0·078
October ...	72·6	76·0	80·1	89·6	83·8	80·5	78·3	80·4	82·1	85·8	82·6	82·2	17·4	17·2	0·099	0·072
November ...	65·4	69·3	74·0	83·8	77·5	74·3	71·5	73·9	76·0	78·6	75·8	76·1	15·5	15·4	0·071	0·059
December ...	57·6	61·9	67·2	76·5	69·8	67·5	64·5	67·0	69·5	71·4	68·8	69·5	15·2	15·0	0·050	0·052

NOTE —(1) USA open pan Evaporimeter installed in the meteorological enclosure—height of the rim of the evaporimeter is 14" from ground level.

(2) Piche Evaporimeter installed inside the Stevenson Screen at a height of 4' from ground level. Values converted from ccs. to inches as per I.M.D. circulars.

Silcoorie Sub-Station Meteorological Observations 1957 (Tables 10 to 13)

Table 10

Month	Mean temp. °F		Sunshine in hrs.	Rainfall in inches.	No. of rainy days.	Terrestrial min. temp. °F
	Max.	Min.				
January ...	78.6	54.6	?	3.50(?)*	4	51.4
February ...	76.8	55.0	?	2.16	6	50.3
March ...	87.1	61.2	?	0.37	3	56.7
April ...	90.6	67.9	?	16.65	13	65.0
May ...	88.1	72.0	?	29.51	24	70.6
June ...	89.5	76.4	?	13.52	23	75.1
July ...	89.8	76.7	4.6	27.36	30	75.0
August ...	?	?	5.2	13.10	22	74.2
September ...	89.2	75.6	5.2	19.51	17	?
October ...	87.4	69.9	7.7	4.33	8	?
November ...	85.3	61.2	9.1	0.00	0	?
December ...	79.9	54.0	8.3	0.00	0	?
Total ...				130.01	150	
Average ...	85.7	65.9	6.7			64.8

Note :—(?)* Observation was recorded from 8th January 1957.

Table 11 : % Relative Humidity, monthly averages.

Hrs. I. S. T.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
06 10	96	93	93	88	91	93	95	94	92	94	95	97
13 10	54	45	38	48	71	72	73	68	69	61	47	44

Table 12 : Vapour tension, monthly averages, in inches of mercury

Hrs. I. S. T.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
06 10	0.425	0.421	0.523	0.654	0.778	0.894	0.920	0.925	0.861	0.737	0.539	0.417
13 10	0.447	0.404	0.451	0.638	0.830	0.902	0.925	0·920	0.870	0.740	0.533	0.424

Table 13 : Soil temperature °F and Evaporation from Piche Evaporimeter, monthly averages.

Month	Soil temperature in Bare Plot F						Evaporation from Piche Evaporimeter in inches (1)
	06 18 hrs I. S. T. Depth			13 18 hrs. I.S.T. Depth			
	5 cms.	15 cms.	30 cms.	5 cms.	15 cms.	30 cms.	
January	61.8	65.5	69.0	77.6	70.2	69.1	0.075
February	62.8	66.9	70.4	80.6	72.0	70.5	0.089
March	69.8	74.5	77.9	91.6	80.9	78.1	0.158
April	74.8	78.6	81.9	94.6	85.0	82.5	0.173
May	77.1	79.9	82.3	89.9	84.4	82.5	0.104
June	80.9	82.7	84.9	93.4	87.8	85 3	0.083
July	81.5	83.7	86.0	94 4	88.5	86.2	0.084
August	81.6	83.9	85.9	94 8	88.4	86.6	0.096
September	79.0	81.5	83.8	91.8	85.8	84.4	0.078
October	76.3	79.7	82.8	92.5	85.5	83.3	0.085
November	70.6	75.4	79 3	90.1	82.4	80.0	0.098
December	64.4	69.3	73.4	82.4	75.0	73.8	0.094

NOTE :– Piche (1) Evaporimeter installed inside the Stevenson Screen at a height of 4' from ground level. Values converted from ccs. to inches.

BOTANICAL BRANCH

W. WIGHT—Senior Botanist
D. N. BARUA—Plant Physiologist
M. J. GREEN—Selection Officer
P. K. BARUA—Additional Officer.

STAFF

The Senior Botanist acted as Director from 28 May to 5 October. Mr. M. J. Green was on home leave from 21 April to 16 November. Dr. D. N. Barua visited eleven estates in Assam, Bengal, Dooars, Terai and Darjeeling in connection with problems of vegetative propagation. Mr. M. J. Green assumed the appointment of Selection Officer, and the Senior Botanical Assistant (Mr. P. K. Barua) was promoted to Additional Officer.

RESEARCH AND EXPERIMENT

Systematic Botany :

This year evidence was published to show that some populations cultivated as tea are probably species hybrids (Nature 179, 506-507, 1957). Floral anatomy is being studied on a population basis as a guide to the taxa involved. In connection with this project, Mr. P. K. Barua has shown that important variations of floral anatomy are associated with variations in the sclereids of the leaf, and the Senior Biochemist (Mr. D. J. Wood) has shown sclereid morphology to be associated with chemical compounds that have a critical value in tea taxonomy. This aspect of the investigation is being prepared for publication. It is based upon collections by Capt. F. Kingdon-Ward and points to crossing between tea and other species in the Shan States.

Cultural Value of Populations :

Cells which contain crystals of calcium oxalate are a characteristic feature of the tea plant. A standard count of these crystal-cells has been defined as *phloem index* (Current Sci. 23, 75-79, 1954). Environmentally determined variation

of the phloem index is within genetically controlled limits and a mean phloem index with a standard error is characteristic of an individual plant. Each crystal-cell is characterised by a particular set of chemical reactions that lead to the formation of calcium oxalate crystals. The phloem index has a simple genetical behaviour in crosses and can be the basis of an agronomically useful classification of tea populations without reference to entities defined by a Linnean nomenclatural system. An account of this work is in the press. It is being extended to a study of the efficiency with which nitrogenous manures are utilized by populations that are specified by phloem index. Here, and in what follows, "population" means the progeny of an interbreeding community.

Environment and Survival of Populations:

A short term investigation of the effect of locality on transplants of standard clones was completed in 1957. The phloem index of the clones was altered by locality and clones interacted with locality. An account of this work is being prepared for publication. A more precise long term trial showed alteration of phloem index due to treatment to be significantly associated with death rate. A simple account of this work is in the press at the time of writing (Feb. 1958).

Tea Breeding:

In the sphere of tea breeding earlier reports have dealt with progenies obtained by controlled hand transfer of pollen between two clones. Nearly 200 of these have been under observation in the last decade. Five seem worth testing under estate conditions in various localities. For this it is necessary to produce seed by free natural transfer of pollen in a normal seed *bari* (orchard). This has been done for one cross and sufficient seed has been obtained for the Association's Advisory Officers to begin trials in four widely separated tea producing districts. It is our intention to establish isolated baries of other pairs of clones.

One of the crosses worth testing under estate conditions has repeatedly, from 1953 onwards, made tea at Tocklai with a

noticeable Darjeeling flavour. While Darjeeling flavour is particularly associated with mixed populations of "China" and "China hybrid" plants in Darjeeling, yet it is not a marked feature of tea made from similar populations grown at Tocklai under plains conditions. It would seem likely, therefore, that the flavour of the particular cross might become pronounced in Darjeeling. Trials of this progeny in various tea producing regions should be of great interest.

Selection by Estate Managers :

In addition to clonal seed production, attention has been given to less ambitious but very necessary production of seed on tea estates, in baries established by mass selection of seedlings. Managers are also being encouraged to produce rare teas of scarcity value by the use of vegetatively propagated clones. Both aspects of work on estates are described by W. Wight in a separate article given as Appendix "B" to the botanical branch report.

Interpretation of Field Trials :

Investigation of the death rate of tea bushes has led to the definition of measures, other than the weight of plucked shoots, which might be useful for field trials. This subject was discussed in our report for 1954 (pp. 30-38) where attention was drawn to the significance of bush diameter. This year a more lengthy treatment of the subject is given in an article by W. Wight and L. R. Saikiah, as Appendix "A" to the report of the botanical branch.

Errors due to Green Weight :

Percent dry weight of plucked shoots has been shown (Ann. Rep., 1956, p. 49) to be significantly reduced by shade ; from which it follows that a comparison of the yield of shaded and unshaded plots, if based on fresh weight, is subject to an error. It was with the object of obtaining an estimate of this error that further analysis of data collected in 1956 from Area 8.2 Borbhetta was undertaken.

In this Area four different forms of nitrogenous fertilisers in two doses have been applied in full sun and also under bamboo screens transmitting approximately 50 per cent and 40 per cent of full sunlight. Percent dry weight was determined on pluckings from each of the 96 experimental plots on twenty four plucking rounds. The percent dry weight figures were used for converting fresh weight of plucked shoots into dry weight and the conventional factor of 0.225 was used for converting fresh weight into made tea. When the difference between the two sets of figures was statistically analysed, the gross effect of illumination intensities, shown in Table 1, became highly significant ($P < 001$).

Table 1 : Weights in lbs. for 768 bushes.

Light intensity.	Absolute difference between conventional and true estimate	Percent excess of conventional over the true estimate.
100% (full light)	181	4·0
50%	385	9·0
40%	359	8·9
Difference between light intensity required for P = ·05	65·6	———

If the difference of 4 percent in full sun between the two sets of values be attributed to the moisture content of made tea, then any difference in excess of 4 percent is an over estimate. The difference under the two reduced illumination intensities being 9 percent, use of the conventional factor for converting fresh weight of shoots plucked from shaded plots into made tea, has introduced a positive error of 5 percent. In other words an increase to the extent of 5 percent in the weight of fresh shoots under shade over that in full sun, does, in fact indicate *no* real increase in the weight of finished tea.

It should be noted however that in our field trials involving shade, the difference in the yield of fresh shoots between shaded and unshaded plots, almost without exception, is very much in excess of 5 percent ; so that our conclusions regarding the value of shade are unaffected by the above results. Nevertheless, in the light of these findings it would be more appropriate to use

a factor less than 0.225 for converting fresh weight of shoots from shaded sections into made tea, retaining the factor of 0.225 for unshaded sections. On the basis of the above observations, the conversion factor for shaded tea works out at 0.214.

Even if the increase in yield due to shade is real, there is a disproportionate increase in the amount of water. Hence a correction of the nature indicated above is necessary for assessing the requirements of a factory to deal with the excess quantity of water in shoots from shade grown plants.

Trials based on Young Plants :

Young plants belonging to four different clones, which were pruned in 1956 at the end of their third year of growth (Ann. Rep. 1956, p. 35), were tipped and plucked over four leaves at fortnightly intervals, commencing on 1-5-57 and ending on 28-11-57. The fresh weight of plucked shoots was recorded at every plucking round. Statistical analysis of the yield figures shows that annual yield per plant is affected significantly by changes in illumination intensity and also by clones but not by the interaction of the two. The mean yields for light intensities and clones are shown in Table 2.

Table 2: Fresh weight of plucked shoots.

Effect of clones.		Effect of light intensity.	
Clone	Annual yield of plucked shoots per plant.	Light intensity.	Annual yield of plucked shoots per plant.
19/36/15	59·84 gm.	100% (full light	56·95 gm.
20/23/1	71·41 ,,	50%	72·34 ,,
19/29/13	78·58 ,,	35%	66·76 ,,
114/2	40·80 ,,	20%	54·33 ,,
Difference required for P=·05 : 14·47		Difference required for P=·05 : 7·13	

The yield figures for the same plants during their second year of growth were quoted in Table 7, page 42 of the Ann. Rep. for 1956. There has been a five fold increase in yield between the second and the fourth year, without however any change in the relative order of efficiency of the different light intensities or clones. This observation raises the probability of forecasting the behaviour of mature tea bushes from observations made on young plants. Experiments designed to correlate the behaviour of mature tea bushes with growth characteristics of young plants are in progress.

The Nature of the Plucked Shoot :

Tea planters generally attach importance to changes in the plucked shoot brought about by variation of light intensity. Shade is sometimes said to increase the proportion of stem to leaf. Less attention has been paid to level of nitrogen and none to the kind of manure that carries the nitrogen. A separate article by Messrs. D. N. Barua, K. N. Dutta and B. N. Gogoi, given as appendix "C" to the botanical branch report, shows that plucked shoots are profoundly influenced by kind of manure and also by the level of nitrogen.

Shade and Crop Yield :

It was stated in the Ann. Rep. for 1955, p. 30, that a canopy of horizontal bamboo screens significantly increased the yield of a mature tea bush population that had not previously been under shade. The increase in yield, noted within five weeks, was maintained for three years. The experiment (Area 34.3 Borbhetta) has now completed seven years. The yield increment due to bamboo screens transmitting approximately 50 per cent of full sunlight is shown in Table 3. Each figure in the table is the mean of four repeats. None of the plots received any form of nutrient during the period of the experiment.

Table 3 : Yield of made tea in Mds. per acre.

Year / Treatment	1951	1952	1953	1954	1955	1956	1957	Average for 7 years
Bamboo screen shade	11·85	12·25	10·03	11·11	12·66	11·65	11·86	11·63
Full sun	7·54	7·34	5·99	6.93	6·87	6·53	6·98	6·88
Increase due to bamboo screen	4·31	4·91	4·04	4·18	5·79	5·12	4·88	4·75
Percent increase over full sun	57·2	66·9	67·4	60·3	84·3	78·4	69·9	69·0

Yield increase due to bamboo screens is highly significant every year. Bamboo shade, on the average, has increased crop by 69 percent over full sun.

Figures in the above table have been computed by multiplying fresh weight of crop by a factor (0.225) common to shaded and unshaded plots, ignoring the higher moisture content of shoots from the shaded plots. However, the error introduced in this way has already been shown to remain within 5 percent of the yield of the unshaded plots. When allowance is made for this computational error the difference between the shaded and the unshaded plot still remains at 4.51 mds. made tea per acre and this increase is due entirely to the bamboo screens.

PUBLICATIONS

Wight, W. & Barua, P. K. What is Tea? *Nature* **179**, 506-507 (1957).

Wight, W. & Gokhale, N. G. Assam Tea looks Ahead *Amrita Bazar Patrika,* September 24 (1957).

ADVISORY AND GENERAL

Fifty-six technical memoranda were dispatched to Estates and approximately 300 similar memoranda were received from the Advisory staff for comment. Dr. D. N. Barua wrote a long report on his tour in West Bengal. About 50 directives were received from the central headquarters office. One member of the laboratory staff was engaged for approximately three months supervising labour at Borbhetta. Inspections at Borbhetta occupied the Senior Botanist for approximately one month.

Staff responsibility has been extended to include advice and assistance to estates in all matters connected with selection of vegetative clones and also with the selection of seedlings suitable for new seed baries. The botanical officer in charge of this work (Mr. M. J. Green) has been designated Selection Officer.

APPENDICES TO THIS REPORT

APPENDIX "A"

Measures of the Tea Bush in Agricultural Trials

By W. Wight and L. R. Saikiah

Agricultural trials of tea bushes (*Camellia sinensis* L.) are subject to numerous errors, particularly when conducted on tea estates. Some errors inevitably follow the precautions which are taken to avoid border effects. If experimental plots are completely contiguous one with another there are no border effects but the boundaries are obscure. If the plots are widely separated then each must have a periphery of unwanted bushes known as a guard line. In either instance the plucker needs to be fully aware of bushes which are not part of a particular plot. Such awareness is not a characteristic of estate labour, and knowledgeable supervision becomes necessary on each of the 30 to 35 occasions per year when it is customary to pluck the bushes. This supervision is usually beyond the capacity of an Estate staff; neither is it possible for an extension (Advisory) Officer from the Experimental Station to be present at the plucking of each of the widely dispersed trials in a district. Thus confused plucking of plots is possible and may cause errors in the records of Estate trials. A lesser number of pluckings might be properly supervised, and it is questionable whether the traditional number of pluckings is necessary. The answer may sometimes be in the negative, judging by the observation that a much smaller number of pluckings can define genetic levels of yield[1].

While a smaller number of occasions might make plucking more accurate, it would not eliminate all the errors. Plucking is commonly repeated in a directional manner, from one end of a block to another. The first plots may be plucked before and the last after a heavy downpour of rain. The rain water causes errors of weighment, possibly repeated in some plots more than others. These errors cannot be eliminated when dry weight records are not kept, as they never are in tea estates. The green weight of prunings need not be subject to such errors; and prun-

ing weight could convey useful and perhaps more accurate information.[2]. Prunings are superior to pluckings as a measure of increments to the bush frame, upon which yield necessarily depends.

In the tea plant, weight of growth has special significance when expressed as a ratio of the frequency (in the phloem of the leaf petiole) of cells containing crystals of calcium oxalate. This frequency has been defined as *phloem index*[3] and the ratio as *unit weight*[4]. The latter is the ratio of observed weight to observed frequency of special cells the possible frequency of which is genetically determined[3]. It has been shown that unit weight is associated with the survival of bushes under shade conditions[4]. It is possible that changes in unit weight under any conditions may be reflected in survival rate. Thus it becomes essential to examine both unit weight and absolute weight of prunings as measures of the bush. The necessary phloem index can be determined in the laboratory at any time from preserved petioles which need be collected only once. This simple condition should be borne in mind, as all statements about phloem index which follow are based upon one examination of petioles collected on only one occasion.

Some relevant data are given in Table 1. This shows an analysis of variance repeated in terms of absolute weight of prunings, absolute weight of pluckings, and the sum of the two; and then again for the ratio of each of these three factors to phloem index. The phloem index itself is analysed, and in this connection it is to be noted that the analysis gives a slightly different result from one based on an earlier cell count of the same trial[3]. This does not affect the present argument.

Table 1 shows unit weight of prunings to be superior to crop yield (pluckings) in respect of information about the status of the bushes. Given such an analysis it might be sufficient to estimate the magnitude of the yield without actually measuring it.

An estimate of crop yield is made possible by the existence of a correlation between crop yield and pruning weight.

Table 1: Analysis of variance of Area 45/47, (Borbhetta, 1951) repeated for seven measures of the bush. The data are "F" values greater than unity: lesser values are ignored. One asterisk indicates significance at the .05 level, two at the .01 level and three at the .001 level. Sources indicated by "J" for jat, "S" for shade, "N" for nitrogen: vide Ann. Rep. 1954, pp. 30-38.

Source	D.F.	Phlœm index (Pi)	Total growth (P+C)	Prunings (P)	Pluckings (C)	P/Pi	(P+C)/Pi	C/Pi
Replicates ...	2	56.70***	2.49	3.73	1.55	8.38*	5.22*	2.99
J × N ...	3							
Shade ...	1	...	41.33**	45.46**	35.85**	24.12**	22.28**	23.14**
J × S × N ...	3	...	...	...	...	...	...	...
Error ...	2							
Sub-blocks ...	11	12.41***	15.81***	6.94***	44.62***	10.36***	12.57***	17.54***
Nitrogen ...	1	13.32***	122.31***	82.82***	158.33***	88.26***	80.72***	62.47***
Jats ...	11	14.56***	1.31	1.26	2.53**	4.32***	5.28***	5.35***
S × N ...	1	...	42.47***	38.69***	21.82***	15.79***	8.36**	6.94**
J × S ...	11	1.18	...	...	...	2.15*	2.49**	1.27
J × N ...	11	1.37	...	...	...	1.43	1.51	...
J × S × N ...	11	...	...	...	...	1.30	1.41	...
Error ...	86	...	...	...	...	...	...	...

Table 2 shows the magnitude of the possible correlations expressed in terms of the analysis of variance. The analysis deals

Table 2: Correlation coefficients associated with the analysis of variance in Table 1. Unit weight of prunings (P/Pi), absolute weight of prunings (P) and phloem index (Pi) are each correlated with crop yield (C). Asterisks indicate significance as before.

Source.	D. F.	P/Pi	P	Pi
Replicate	2	0.64	0.89**	−0.26
J×N	3			
Shade	1	1.00	1.00	−1.00
J×S×N	3	0.98***	0.96***	−0.75*
Error	2			
Sub-blocks	11	0.78**	0.96***	−0.16
Nitrogen	1	1.00	1.00	−1.00
Jats	11	0.00	0.27	−0.07
S×N	1	1.00	1.00	−1.00
J×S	11	0.59*	0.48	−0.47
J×N	11	−0.28	−0.17	0.28
J×S×N	11	0.51	0.44	−0.23
Error	85	0.53***	0.54***	0.03

with interactions, whereas estate practice is based upon the direct effect of nitrogen in full sun, nitrogen under shade, and shade trees alone, each relative to a control the absolute value of which is often immaterial. The direct effect of nitrogen under shade is not given in Table 1 because the particular trial is not designed to give an estimate of the variance associated with the specific treatment of nitrogen under shade. But knowledge gained over many years leaves no doubt that the four treatments do result in different crop yields, and it is therefore considered justifiable to plot treatment yields directly against treatment prunings in Figs. 1 and 2. The correlation co-efficient is 0.90 for absolute weight of prunings and 0.88 for unit weight of prunings, each correlation being in terms of block totals. In terms of the same block totals, crop yield is not correlated with phloem index.

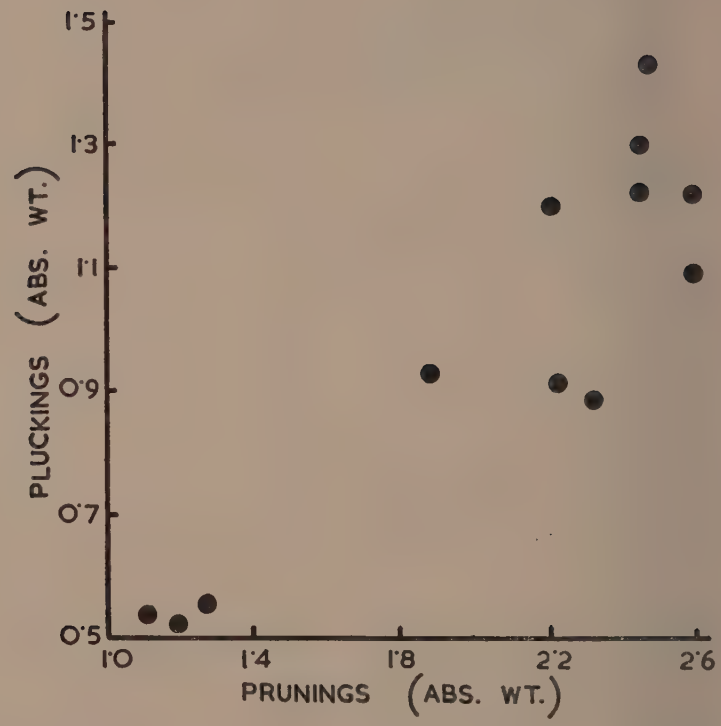


Fig. 1: *Correlation between absolute green weight of prunings and absolute green weight of pluckings, both expressed as kilogrammes per bush. Three points are derived from control, and three from each of the treatments "nitrogen", "shade" and "shade plus nitrogen".*

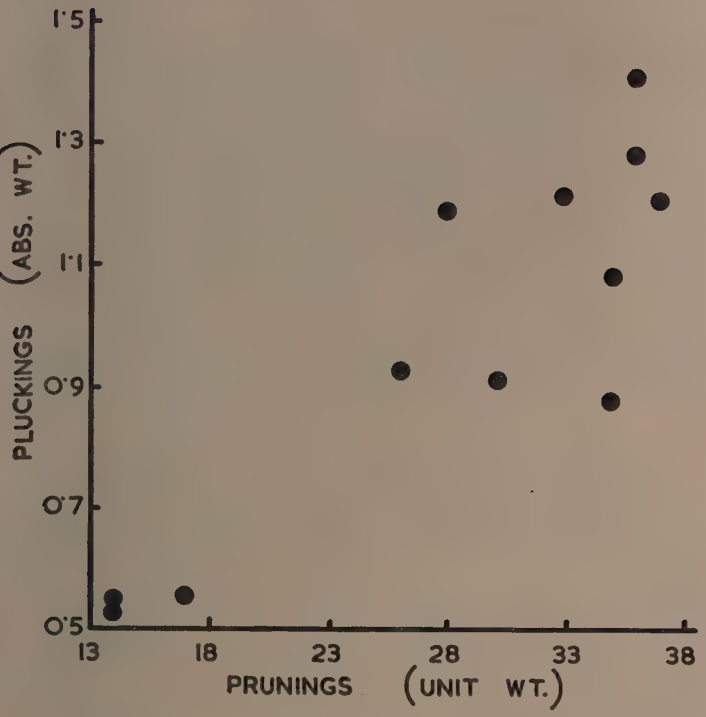


Fig. 2: Correlation between unit green weight of prunings, expressed as grams green weight per unit crystal, and absolute green weight of pluckings expressed as kilogrammes per bush. Three points are derived from control, and three from each of the treatments "nitrogen", "shade" and "shade plus nitrogen".

Table 2 shows a significant intrinsic correlation between crop yield and pruning weight. This makes it possible to adjust the analysis of variance and see if plucking weight can be considered entirely dependent upon pruning weight.

The analysis of covariance applicable to the lower part of Table 2, is given in Table 3. It shows a significant S × N interaction after adjustment on the basis of unit weight of prunings. The physiological interpretation of this is likely to be important but it is beyond the scope of our present argument. Here we can confine our attention to yield adjusted on the basis of absolute weight of prunings. When this is done, treatment interactions vanish (Table 3) showing that, *in terms of inter-*

Table 3: Analysis of covariance of Area 45/47 (1951). Data for crop yield (pluckings) adjusted on the basis of unit weight of prunings and on the absolute weight of prunings, vide Table 2. The figures shown are "F" values.

Source.	D.F.	Yield adjusted on unit weight	Yield adjusted on absolute weight
Replicates ...	2	...	...
J × N ...	3		
Shade ...	1	...	...
J × S × N ...	3	...	...
Error ...	2		
Sub-blocks ...	11	...	...
Nitrogen ...	1	39.36***	41.60***
Jats ...	11	4.65***	3.32***
S × N ...	1	7.55**	1.59
J × S ...	11	...	...
J × N ...	11	1.57	1.04
J × S × N ...	11	...	1.02
Error ...	85	...	...

actions, pluckings can be completely associated with prunings. A jat effect remains, but this does not materially alter our argument when the interactions have vanished. We are however concerned with specific cultural treatments rather than interactions (Figs. 1 & 2) and as a significant part of the total yield due to nitrogen cannot be associated with pruning weight, therefore some error is inherent in our predictions of yield made on the basis of pruning weight (Figs. 1 & 2). However, the point we wish to make is that analysis of variance could in the first place be done in terms of absolute and unit weight of prunings: it need not then be subject to estate errors; and such an analysis can provide a valuable practical prediction of the results to be expected in terms of crop yield. The prediction could be confirmed by direct observation if necessary. The unit weight of prunings would convey information about potential longevity of the bushes which might be reflected in long term trends of yield.

The foregoing paragraph, have shown pruning weight and phloem index to be desirable criteria which can serve, in some instances at least, for the prediction of yield and so simplify the management of a trial. Emphasis has been given to certain shortcomings of plucking weight in the particular circumstances of estate trials; but it is for consideration whether adequate information can, in any circumstances, be given by plucking weight alone?

The information that can be obtained from measures other than crop yield can be illustrated by a field trial at Borbhetta[5,6] in which two standard doses of nitrogen, 75 and 150 pounds per acre, were applied as each of the four manures, ammonium sulphate, calcium nitrate, urea, and mustard oil cake. The eight manurial treatments were repeated under three light intensities permanently controlled by a horizontal meshwork of bamboo laths approximately six feet above the ground. The light intensities were 100% (full sun), 75% and 50%. Analysis of variance of pruning weight, plucking weight, phloem index, and associated correlation coefficients are shown in Table 4 which is self explanatory.

Table 4: Statistical analysis of Area 8 (Borbhetta, 1953). Notation the same as Tables 1-3. "F" values are given.

Source	D. F.	Analysis of variance.							Correlation coefficients.		
		Pi	P	C	P+C	P/Pi	C/Pi	(P+C)/Pi	Pi with P	Pi with C	P with C
Blocks ...	3	1.88	3.20	...	2.58	2 29	...	1 66	−0.24	0.11	−0.02
Light (L)	2	9.29*	...	15.33**	1.06	2.48	10.55*	5.17*	−0.07	−0 83	−0.49
Error ...	6	...	...	...	...	...	...	...	−0 06	−0.30	0.22
Total ...	11	...	...	...	...	...	...	...	...	...	...
Manure (M) ...	3	...	1.63	3.84*	2.80*	...	...	...	−0 52	−0.89*	0.83
Nitrogen (N) ...	1	1.08	...	19.72**	4.12*	...	3.67	1.54	−1.00	−1.00	1.00
M × N ...	3	...	3.05*	...	3.44*	1.40	...	...	0.07	0 15	0.89*
L × M ...	6	...	...	...	...	1.11	...	1 09	−0.35	0.38	0.60
L × N ...	2	4.68*	...	...	1.16	3.68*	2.24	3.70*	−0.96*	−0.67	0.83
L × N × M ...	6	2.27*	...	...		1.16	1.32	1.29	0.05	−0.66	−0.14
Error ...	63	...	...	...	...	...	...	...	0.01	− 0.10	0.18

Manures were applied in July 1952, too late for reliable data to be got that year. In what follows, 1953 is described as the first year of the trial, and the statements which are made are based solely on this one year's records of three measures of the tea bushes. We propose to show that all three measures could have been considered necessary for a proper interpretation of the trial.

In the first place we shall refer to the physical meaning of the statistical analysis in Table 4. It is not always fully understood by practical men. Our remarks are with reference to pruning weight, but the principles are of general applicability.

As doses of nitrogen increase one can suppose their effect on pruning weight to have a definite direction. In the present instance the nitrogen is carried by four different kinds of manure. One cannot suppose that doses of these manures will always affect pruning weight in the same direction. In fact, they do not do so ; and this is properly stated as a *manure into nitrogen interaction* (M × N).

One of the factors in the analysis (Table 4) is "Manure". This is supposed to estimate the *general* value of one manure relative to another. The estimate is made by adding together for each manure, the weight of prunings obtained with both doses of manure under all light intensities. There is no significant difference between manures *so defined*. But this picture is obtained by adding together, and *so ignoring*, physical effects on the tea bushes that can be opposed in direction. Estate management depends more on which manure is used in which dosage. Thus the interaction of kind of manure (M) with its nitrogen content (N) conveys essential information ; and the data show clearly, when pruning weight is the measure of the bush that the effect of a unit dose of nitrogen depends upon the kind of manure which carries the nitrogen. Thus the value of a manure cannot be estimated solely from its nitrogen content; and identical doses of nitrogen have a markedly disproportionate effect on pruning weight when the nitrogen is conveyed by different kinds of manure. This interpretation supposes both manure and nitrogen to have a significant effect in appropriate circumstances.

In terms of plucking weight, the gross effect of manure and the gross effect of nitrogen are both significant. But plucking weight is very much more troublesome to get. We have already commented on the possibility of using pruning weight as a measure, and from that deducing plucking weight.

In terms of the total amount of growth removed from the bushes (summated pruning and plucking weight) the general effect of kind of manure and the general effect of nitrogen, and the interaction of manure with nitrogen, all become significant (Table 4).

We now turn our attention to *unit weight* of the total growth : that is, the ratio of summated pruning and plucking weights to phloem index. We have already shown this unit weight to be associated with survival[4]. In these terms, the gross effect of light is significant: so also the interaction of nitrogen with light ; but not the interaction of manure with light. This suggested, in the first year of the trial, that nitrogen as such is likely to be a major factor determining survival under various illumination intensities. At this early stage of the trial the particular kind of manure which carried the nitrogen did not have a significant effect on unit weight, though, as will be described later, the implications of unit weight in 1953 could not be ignored by a physiologist (*vide* Table 7.) It is important to note that the *interaction* of nitrogen with light implies a survival associated with nitrogen dosage at one light intensity that would be differentially altered at other light intensities. A significant interaction between light and nitrogen is demonstrated also by unit weight of prunings, but not by unit weight of pluckings.

The phloem index by itself conveys important information. It defines a frequency of cells that are characterised by a particular set of chemical reactions. And there is now sufficient evidence, either in the press or being prepared for publication, to say that phloem index is a useful definition of a metabolic status, analogous to the status defined in other plants by a carbohydrate to nitrogen ratio. In terms of phloem index the light into nitrogen interaction is significant. Furthermore, it is significantly altered by the kind of manure which carries the nitrogen

($L \times N \times M$). Thus, kind of manure, irrespective of its nitrogen content, must be supposed to have a material influence on the phloem index.

As already explained, a real difference between kinds of manure (in terms of their effect on the tea bush) does not necessitate statistical significance of the variance which is designated "Manure" (M); nor need it depend upon statistical significance of the light into nitrogen interaction ($L \times N$). Provided that the second order interaction ($L \times N \times M$) is significant, then it is impossible to consider one set of cultural conditions in isolation from other sets of cultural conditions, without *attaching importance to kind of manure, to the amount of nitrogen which it supplies, and to the light intensity under which it is used.*

The meaning of the second order interaction transcends that of the first order interactions; and it clearly showed, in the first year, that manure, nitrogen, and light, each has a significance in terms of phloem index. We attach great importance to this measure. If, in practice, one dose of manure is not the same as another; and if, in practice, one shade canopy differs from another, then one must suppose kinds of manure *irrespective of nitrogen content*, to have different effects on phloem index when used in the various practical circumstances determined by shade canopy and dosage. This follows from the second order interaction.

Should the density of the shade canopy on a particular estate not be of any consequence; nor the amount of manure which is used under the canopy; and if, instead, one can be interested only in an average effect over a number of estates which differ much in the amount of manure they use and in the density of their shade canopies; then differences in kind of manure might be of no consequence. This is the picture designated "Manure" (M) in the statistical analysis. Much greater practical importance attaches to the second order interaction.

We have spoken of the second order interaction in terms of phloem index. Sufficient evidence has been published[3] to show that changes in phloem index are likely to be reflected in

plucking weight. One might therefore suppose phloem index likely to forecast future trends of yield. This possibility is supported by the correlations (obtained in the first year) between phloem index and plucking weight. The correlation in terms of the second order interaction (—0.66) was of marginal significance but should not on that account be ignored.

We now turn to a somewhat more fundamental problem : under what nutrient conditions does a reduced light intensity cause the biggest increase of yield? For physiological purposes this problem needs to be considered independently of absolute level of yield. One should also consider the effect of shade on the permanent parts of the bush, with implications of survival. It will be convenient to deal with yield increase first.

In this connection we divert our attention to the more recent yields of 1957 as being likely to give us a better picture of nutrient status of the plots. The plucking weight for 1957 is shown in Table 5 in terms of totals for the four blocks, the two nitrogen doses being summated for each manure. The initial 75% and 50% light intensity established in 1953 had been changed to 50% and 40% respectively, but this does not materially affect our argument.

Table 5: Increase in plucking weight (yield) due to shade in the presence of four manures. Yield as kilogrammes green weight per hectare, summated for two doses of manure. Data for Area 8, 1957.

Manure	Absolute yield in full sun.	Increase over sun due to shade.	
		50% light	40% light
Oil cake	4721	741	248
Ammonium sulphate	4432	916	424
Calcium nitrate	3857	913	766
Urea	4000	851	710

It will be seen (Table 5) that calcium nitrate and urea are better than the other manures at a low light intensity in terms

of relative increase of yield. This superiority appears greater by paying attention to the nitrogen dosage appropriate to a particular light intensity, instead of summating two arbitrarily chosen doses, as was done in Table 5. For instance, the higher of the two nitrogen doses when applied as calcium nitrate, depresses plucking weight under low light intensity. Comparisons between doses which give maximum yield under each light intensity, are made in Table 6.

Table 6: Increase in plucking weight (yield) due to shade in the presence of four manures. Yield as kilogrammes green weight per hectare, due to the better dose of manure at the particular light intensity. Data for Area 8, 1957.

Manure	Absolute yield in full sun	Increase over sun due to shade.	
		50% light	40% light
Oil cake	5502	353	−268
Ammonium sulphate	4806	773	168
Calcium nitrate	4001	878	769
Urea	4050	942	855

The data in Tables 5 and 6 lead to the conclusion that the chemical compound which carries the nitrogen becomes a matter of great importance at low light intensities. The data support the hypothesis[7] that nitrogen in the form of an organic molecule is important at low light intensities. It has also been suggested[7] that organic molecules, of which urea was taken as a simple example, enter the tea plant in greater numbers the lower the light intensity. It was further suggested[7] that this phenomenon would be conditioned by mycorrhiza. The original intention of the trial under review was the investigation of these problems. They still seem to be of fundamental importance.

The data suggest that calcium has special significance in relation to nitrogen under shade. In this connection it is to be noted that our genetically conditioned scale of phloem index is

also a scale of intensity of certain chemical reactions the final stage of which is dependent upon calcium. The phloem index is a count of calcium (oxalate) crystals. They have been shown to be significantly related to survival under shade.

Our interest in Tables 5 and 6 has particular reference to what might have been inferred in the first year of the trial (1953). The unit weight for that year in terms comparable with Tables 5 and 6, is given in Table 7. At that early date it indicated a superior effect of shade in the presence of urea.

Table 7: Increase in unit weight of prunings plus pluckings due to shade in the presence of four manures. Data for Area 8, 1953, comparable with that in Table 6.

Manure	Unit weight in full sun.	Increase of unit weight due to shade	
		75% light.	50% light
Oil cake	12.60	2 85	2 96
Ammonium sulphate	14 10	−1.84	2.29
Calcium nitrate	11 08	1.66	4.51
Urea	9.59	4 96	4.60

Unit weight under shade can be supposed to forecast death rate. This would eventually influence yield. Thus it is possible that the order of unit weight observed in the first year of the trial may become the final order of yield (plucking weight). While this remains to be seen, it is clear from Table 4 that phloem index alone indicated several features that are becoming evident only after many years when observation has been restricted to the single measure of plucking weight.

We conclude that forecasts based upon phloem index might often be of practical value, but only in rare instances could any single measure of the bush convey adequate fundamental information. The terms in which a trial is conducted determine its duration and efficiency. In terms of plucking weight, duration is not necessarily at a minimum nor efficiency at a maximum.

We are indebted to Mr. S. K. Dutta (Senior Agriculturist) for the yield data on which our analyses are based. The trial in Area 45/47 was initiated by Mr. H. R. Cooper, formerly First Chemist of the Association, and designed by Dr. F. Yates. The trial in Area 8 was initiated by Dr. W. Wight and designed by Mr. S. C. Barua. The opinions expressed in this article are those of the senior author, the statistical work that of the junior author.

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APPENDIX "B"

Selection Policy in Tea Estates of North-East India.

By W. Wight

Selection of tea plants in north-east India is directed towards quality. In the ultimate analysis quality can be determined only after the tea has been made. Were nothing more known, then every tea bush that appears to be a good grower would of necessity need to be manufactured. Fortunately, pubescence of the leaf is an index of quality[1] in the populations commonly cultivated in the plains. Thus visual selection of pubescent plants reduces the number of bushes the shoots of which need to be manufactured. While the cash value of quality is necessarily dependent on yield, we propose in this article to deal mainly with the former factor.

In describing the selection policy in north-east India it can be said at the outset that nothing is known of visual selection for the special attribute of Darjeeling flavour. The Senior Biochemist (Mr. D. J. Wood) has shown conclusively that Darjeeling flavour is an attribute of "China" and "China Hybrid" plants[2] described by Wight and Barua[3] and is not found in populations such as those cultivated in the plains, which approximate more to the Assam variety[1]. Selection within the Darjeeling populations is not understood. At the moment it is only possible to say that selection for pubescence in Darjeeling may do no more than increase the amount of tip in the made tea; and it is possible that such selection may sometimes be detrimental to quality and flavour. There is a belief that Darjeeling flavour is connected with anthocyanin pigments. There is some foundation for this; and we have in fact said that a certain balance of anthocyanin pigments seems desirable in the populations cultivated in the plains[1]. But deliberate selection of pigment in Assam or Darjeeling is likely to *reduce* both quality and flavour.

Having briefly indicated the situation in Darjeeling we can proceed to the methods of selection practiced in the plains. These have a significant positive effect; and while data in support of this statement will be given, it is also to be understood

that better methods may become possible, though they would probably be unsuitable for use by the layman. Our object in this article is to describe the outcome of methods that can be practiced on estates, and to say that selection is necessary there.

It will be convenient to refer briefly to work at the Tocklai Experimental Station[1]. There, progenies resulting from the cross mating of two clones have been chosen for vigour, homogeneity of growth habit, bush diameter, and size of the plucked shoot. Clones suitable for the production of these progenies can be called *generative clones*. The choice of such clones is based upon experimental breeding possible only at an experimental station. But comparatively simple selection among populations existing on estates leads to clones which make tea of rare quality and flavour with a scarcity value in the export market[1]. If mated *inter se* progenies of these clones would frequently be too heterogenous in growth habit to be generally acceptable. The clones can, however, be propagated vegetatively and a plantation made with cuttings instead of seed. Clones used in this way must be especially easy to propagate. Their practical use has already been described[5].

Clones intended to replace seed are known as *vegetative clones*. The use of seed from generative clones should be complementary to the use of cuttings from vegetative clones. Both possibilities should be pursued simultaneously, one by a specialist staff, and the other by estate staff guided by an extension Officer connected with the specialist staff.

On an average, every fifteen acres of tea plantation in north-east India can be supposed to contain one bush that is a potential vegetative clone yielding tea that would command a ready sale in almost any market. Many more bushes might have the quality that we indicate, but only one would be suitable in other ways. It is possible for estate staff to select the quality bushes and develop the good clones with very little technical assistance.

Several distinct kinds of tea can be made by choice of appropriate clones. By this we imply the possibility of kinds of north Indian tea other than those known as Darjeeling and

Assam. More kinds of tea might be desirable in an export market. The sales advantage of competitive brands is fully understood in the marketing of other products. In the case of Indian tea the only possibility of introducing real novelties in the near future lies in the use of clones.

One clone is found to grow better in one locality than another, and so there is need for numerous clones, best selected locally under estate conditions[5]. A suitable balance of clones in a plantation could yield a ready blended tea.

The market possibilities of clones could be put to the test in plantations of the order of one sixth of the area of an existing estate : that is, an area sufficient to engage the factory for one day per week. In the present state of our knowledge it would be unwise to use only one clone, and the suggested area could be planted with several clones that a taster thinks could be used together to make a blend. Alternatively, depending upon manufacturing facilities, the tea from the various clones, could be kept separate. The details would need to be considered afresh in each case, and would include the tasters opinion of the available clones and a routine that would be convenient in the factory. Such details could be considered by Tocklai Advisory Officers when an estate has a nucleus of three to five clones, each large enough for replanting 10 to 20 acres per annum.

Provided that clones can be found with flavour and quality acceptable to growers, then vegetative clones could probably replace seed in the hills. By "hills" we mean conditions under which trees such as oaks, rhododendrons and magnolias grow naturally. We do not wish to give the impression that clones in the plains would be unsatisfactory: that is not so: they have been successfully cultivated at Tocklai for over twenty years. But tea would not grow naturally in the locations of many plains estates: the success (if that is an appropriate expression) of many plains estates has depended more upon differential survival among heterogenous populations than has been the case in the hills, where tea and other camellias find conditions more generally approaching those of their natural habitat. We therefore feel that clones could be used much more extensively in the

hills than in the plains. Clones in some plains locations might need more frequent replanting than has been usual; yet they could pay handsome profits, fully justifying such replanting; but until more experience has been gained it would be unwise to plant an entire estate with clones. We do not visualise much risk in the hills. It is however to be understood that no plains estate has established a clonal plantation even approaching the area that we suggest. The trend in the hills, unfortunately, is towards seed production from plants selected on uncertain criteria.

Courses of instruction in the selection and propagation of vegetative clones have been conducted at Tocklai since 1948 with object of encouraging selection on estates. However some clones are selected at Tocklai. At the time of writing (February 1958) a batch of eight clones is being multiplied for release to members of the Association. They are intended to stimulate estate selection and provide useful standards of comparison.

On estates the practice is to select among existing bushes which are sufficiently large to permit relatively critical judgment. The range of population types in any one estate is usually limited. At Tocklai, seed from all possible populations is imported, and selection is done at the seedling stage. In this way the range of genetical factors is wide: but selection of seedlings is less certain than selection of bushes. However as similar criteria are used in both cases, the results obtained at Tocklai can be used to illustrate the possible efficiency of selection on estates.

On the basis of initial judgment and the subsequent vegetative propagation which is part of the selection procedure, 56 clones raised from seedlings reached the final stage of a field trial at Tocklai in 1957. Tasters reports and yield records are summarised in Table 1 where quality is either "acceptable" or "rejected" according to the author's judgment of tasters reports relative to extensive knowledge of the control. In the terminology of the table the control had acceptable quality, high yield and acceptable growth. It is a clone of proven merit, with quality better than the best commercial jats (seed populations).

In the table, yield refers to the crop of plucked shoots and "growth" means general vigor of the stems and particularly the condition of the bush frame. It is possible, especially with young plants, to get a good yield from a poor frame.

About 60% of the selections had quality as good as or better than the control but yield was selected with less certainty. The data are for the first year in which shoots were available for manufacture. Longer trials might reduce the number of clones which seem to have desirable quality, but sufficient would remain to have made the field trial and miniature manufactures worth while. This justifies the selection procedure.

Roughly 5% of the selections (4 + 1 in Table 1) seem desirable in all respects. A further 5% or thereabouts (6) seem to have somewhat lower but still acceptable yield with superior quality. Without visual selection only a fraction of 1% of the original plants would make desirable clones. Our general estimate for estate selection, allowing for contingencies, is that one bush in 40,000 *of a population known to be good as a whole* will make a first class clone, superior in all ways. In our selection, the one clone superior to all others (Table 1) was selected from about 20,000 plants.

Not all of our members are able to practice vegetative propagation but their estates can be notably improved by using the superior seed sold by specialist tea seed companies[1]. This however is well known, and so demand exceeds supply and superior seed may be unobtainable. Thus routine replanting of estates is necessarily done with available seed, irrespective of its influence on future quality. To meet this situation we have suggested that estates establish their own seed baries by mass selection similar to that followed by specialist tea seed companies, but using the particular criteria developed in Java[6] and at Tocklai.[1]

Table 1 is the result of such selection. In this table, each clone is derived from a seedling. All the seedlings were accepted in the first place and later were subject to the more stringent test of manufacture. In mass selection, they would all have

Table 1: *Frequency distribution of acceptable quality and yield among 56 clones raised from selected tea plants. Position of the control indicated by heavy lines.*

Quality.	Either yield or growth inferior.	Both yield and growth acceptable.	High yield with acceptable growth.	High yield with more robust growth.	Exceptionally robust growth with high yield.
Superior	—	6	1	—	—
Acceptable	16	5	4	2	1
Rejected	15	—	1	3	2

gone into a seed bari (orchard) without further testing. Reference to the table will show that the average quality of all the selected material is approximately the same as the control. It is known that the quality of a mean plant of a progeny is approximately that of a mean parent (within limits) ; and thus one can suppose mass selection capable of reproducing the standard of quality so far set by the best seedsmen. Quality alone, however, is not sufficient. Homogeneity of growth habit is important: thus, in estate practice ones selection would be confined to seedlings raised from a seed source of known growth habit. A set of plants of miscellaneous origin, such as those in Table 1 would be likely to produce undesirably mixed progeny. The table however suffices to show that suitable mass selection tends to isolate quality factors.

The selected plants in Table 1 were raised from 99 seed baries representing most of the seed sources in northern India in 1947. It would be of interest to know the quality status of similar *unselected* populations. By manufacturing the shoots of fully mature individual bushes in random samples of comparable populations (raised from 54 sources) the data in col. 1 of Table 2 were obtained. This is the distribution of quality in an average unselected population in northern India. It can be compared with the data in col. 2. The second column gives the effect of selection among populations similar to those in col. 1. The number of unacceptable bushes has been reduced by half: the number of acceptable bushes has been more than doubled; and there has been a four fold increase in the number of superior bushes.

The foregoing results show that the inferior material of an average seed source can be improved by simple selection. It is, however, relevant to ask how this selection compares with that already done by specialist seed growers? The comparison is made in col. 3 of Table 2. There we show the quality distribution of bushes in one of the best jats on sale to-day. Comparison of the two columns indicates that mass selection among populations characteristic of the tea industry in north India results in populations similar to those sold by reputable seedsmen. Mass selection, in fact, is the method practiced by these seedsmen, though their criteria are not necessarily the same as those at Tocklai.

Table 2: Association of Assam quality with pubescence, in tea plants of the plains of north-east India.

Quality.	Representative jat populations (Stock 19) Manufactured mostly 1950.	Plants (clones) selected by W. Wight from similar populations (Area 60) Manufactured 1957.	Single high grade jat Manufactured 1937	Theoretical possible selection from high grade jat. Based on 1937 data	Actual selection by L. R. Saikiah from high grade jat, 1951. Clonal repeats manufactured 1957	Tocklai standard clones	Possible quality clones.
	Pubescence heterogenous.	Uniformly pubescent	Pubescence heterogenous.	Uniformly pubescent.	Uniformly pubescent.	Not necessarily pubescent.	
Superior ...	1.2	5.2	10.9	18.1	26.3	0.0	100.0
Acceptable ...	19.9	55.2	33.7	40.0	36.8	100.0	0.0
Rejected ...	78.9	39.4	56.3	41.8	36.8	0.0	0.0

Comparison of cols. 2 and 3 has only limited validity. The selected plants seemed similar in pubescence; but the jat is the *progeny* of selected plants (selected by seedsmen) and within this progeny there in considerable variation in pubescence.

The plants in col. 2 were *seemingly* similar in pubescence. But if allowed to breed freely among themselves the next generation would exhibit considerable variation, some plants becoming glabrous or nearly so. The quality of a mean plant might not be much altered. In respect of quality and pubescence the progeny might be rather similar to the commercial jat. These observations raise the important question of the effectiveness of further selection in good commercial jats : can selection for pubescence in such jats bring about an increase of quality?

The possible limits of such selection were estimated in 1937 by separate manufacture of shoots from a large number of fully mature bushes, the pubescence of which was determined by replicate observations. The bushes with top grade pubescence gave the quality distribution in col. 4 of Table 2. This is the selection theoretically possible.

Later, in 1951, an assistant (Mr. L. R. Saikiah) examined a similar population in another location. This time approximately 5,000 bushes were examined in the space of a few days. The selected bushes were propagated vegetatively and replicated clones manufactured in 1957. These gave the quality distribution in col. 5 of Table 2, which is in good agreement with expectation.

It is, however, improbable that tea estate staff would give the concentrated attention necessary for selection to be so successful. In most instances selection would do no more than maintain the standard set by commercial seedsmen. But, in view of what we have said of the shortage of tea seed, it would be a real advantage to establish baries equal in quality to those now monopolised by tea seed companies. Our data suggest that selection by these concerns is not as good as it might be, possibly because of undue concentration on features pleasing to the eye but with no bearing on the manufactured product.

The last two columns of the table give comparisons with clones. The cash value to be associated with levels of quality depends upon market conditions. The total cash value of any column in Table 2 will be the sum of the products of frequency and cash value. At the time of writing (Feb. 1958) market conditions are such that a Tocklai *standard clone* would give a bigger cash return per hectare (or acre) than the highest grade jat. Under some market conditions a jat such as that theoretically possible (col. 4) might be more valuable than the standard clone. It is, however, evident that selected bushes in the superior quality class could always be propagated vegetatively and so lead to the condition in col. 7 which would be satisfactory under any market conditions *provided that the clone could be propagated without difficulty and had a suitable yield.* Clones that satisfy these conditions have been produced and can be released to members of the Association as soon as stocks are multiplied. If they meet expectations they should remain superior to any seed population that is likely to be produced in the foreseeable future.

These comparisons with clones call to mind the progeny populations raised from successful bi-clonal matings[4], which, while not as uniform as a clone, may be expected to be more uniform than a commercial jat. Clonal seed from generative clones can result in progeny populations in which a high percentage of bushes are in the superior quality grade. So far, such populations have been unsuitable for general cultivation. Progeny populations in which the bushes are scarcely distinguishable from one another and which mostly fall in the "acceptable" quality group, are known: they have excellent vigor and yield much above normal. Other populations with the average bush between "acceptable" and "superior" quality, are known: they may prove to have satisfactory vigor and yield. But, as emphasised in the early part of this article, seed production of generative clones has only now reached the developmental stage. It will necessarily be five to ten years before seed can be marketed. There is therefore, a clear case for the immediate exploitation of vegetative clones as advised by us ten years ago.[7]

Turning now to the policy which should govern mass selection of plants for estate seed baries. Such selection can be desirably efficient, but is best regarded as a temporary expedient to be employed after balancing long term seed requirements against the time at which a mass selected bari would come into bearing, taking into account the time at which better seed from Tocklai generative clones might come into the market. It is presumed that clonal seed would be produced by specialist seed companies[7] who, naturally, have the facilities needed to most rapidly develop and make generally available, the improved seed that we expect from some of the generative clones now awaiting trial. The time factor is such that mass selected baries may be essential in some estates. But we suggest that the time factor should be very carefully considered, because such estate baries are certain to become of reduced value, whatever immediate improvement they may effect.

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APPENDIX "C"

Nature of the Plucked Tea Shoot Conditioned by Shade and Manure

By D. N. Barua, K. N. Dutta and B. N. Gogoi

Changes in weight of the component parts of plucked tea shoots are reflected in the composition of the finished tea. Various changes within a shoot are ascribed to environmental causes, but there appears to be a general lack of appreciation of the relative importance of causative factors. The observations reported below were intended to assess the influence of illumination intensity, forms and doses of nitrogenous fertilisers and time of the year on the proportions of the constituent parts of a plucked tea shoot.

Random samples of 190 gms. of fresh leaf were drawn from the plucking baskets, brought to laboratory and each sample of shoots was divided into the following component parts:

1. Bud.
2. Internode (piece of stem) between the bud and the first leaf.
3. The first leaf.
4. Internode between the 1st. and the second leaves.
5. The second leaf.
6. Internode between the 2nd. and the 3rd. leaves.
7. The third leaf.
8. Internode between the 3rd. and the 4th. leaves.
9. The dormant shoots, commonly known as *banjhi* shoots.
10. Broken pieces of leaves and stems.

The ten components were dried separately to constant weight in an oven at 100°C and weighed.

The observations were repeated on three plucking rounds, once each in the 3rd week of June, the 4th week of July and the 3rd week of October, 1957. Forty-eight samples were drawn on every occasion from Area 8.2 Borbhetta, in which four forms of nitrogenous fertilisers in two doses had been applied in full sunlight and also under two types of bamboo screens transmitting approx. 50 and 40 percent of full sunlight. Each treatment was repeated four times in space, bringing the total number of plots to ninety-six. The particular observations included only those plots which were manured with sulphate of ammonia and mustard oil cake at 75 lb. and 150 lb. nitrogen per acre.

The plots were plucked on strict seven-day rounds without any breaking back. The mean percent contribution of the various components towards the total crop is shown in Table 1.

Table 1: *Percent contribution of various components towards total crop.*

Components of plucked shoots.	Dry weight as percentage of the total.
1	13.7
2	2.5
3	23.4
4	7.1
5	24.9
6	5.6
7	2.5
8	0.5
9	11.9
10	7.8
Total	99.9

Over 60 percent of the crop is made up by the buds, first and second leaves, the banjhies contribute more than 10 per cent and the stem portions, about 15 per cent of the total crop.

The data were subjected to an elaborate analysis of variance; only the relevant and significant part of the analysis is presented in Table 2.

Table 2: Analysis of variance. Dry weight per 190gm. of fresh shoot.

Sources of variance.	D.F.	S. S.	M. S.	F.	P.
Repeats, Light intensity, kind & dose of manures, date of plucking and their interactions.	143	113.159			
Components,	9	15195.261	1688.362	1896.822	<0.001
Light intensity × component	18	35.779	1.988	2.233	<0.05
Kind (of Manures) × component	9	32.039	3.560	3.999	<0.001
Dose × component	9	23.619	2.624	2.948	<0.01
Date × component	18	3186.859	177.048	198.908	<0.001
Light intensity × kind ×component	18	42.368	2.354	2.644	<0·01
Light intensity × dose × component	18	29.419	1.634	1.836	<0.05
Light intensity × date × component	36	79.744	2.215	2.488	<0.001
Other second and higher order interactions.	189	154.825			None significant
Residual	972	865.221	0.890		
Total	1439	19758.293			

Table 2 shows that date of plucking accounts for the major part of the variance due to the first and the second order interaction with components.

The profound effect of the date of plucking on the composition of the shoots is illustrated in Table 3.

Table 3: Grammes dry weight of components per 100 gm. fresh leaf.

Date / Components	End June		End July		End October	
	Absolute	Percent of the total	Absolute	Percent of the total	Absolute	Percent of the total.
1	6·84	17·6	6·40	15·0	3·28	8·4
2	1·26	3·2	1·19	2·8	0·60	1·5
3	10·90	28·0	10·63	24·9	6·67	17·2
4	3·45	8·9	3·34	7·8	1·81	4·7
5	10·16	26·1	11·64	27·3	8·21	21·1
6	2·15	5·5	2·79	6·5	1·78	4·6
7	0·36	0·9	1·26	3·0	1·43	3·7
8	0·07	0·2	0·24	0·6	0·26	0·7
9	2·24	5·7	2·76	6·5	9·30	24·0
10	1·52	3·9	2·39	5·6	5·46	14·1
——	38·95	100	42·64	100	38·80	100

Difference required for significance at P=.05: 0.38 gm.

There has been a progressive increase in the proportion of the coarser components as the season advanced, which is readily seen from the decrease in the weight of buds and increase in the proportion of the banjhies between June and October. The difference between June and July, however, is relatively small compared to the large difference between July and October.

The significant second order interaction of 'Light intensity × Date × Component' shows that seasonal changes shown in Table 3 can be further modified by changes in illumination intensity. However, such modifications are relatively small (variance ratio of the first to the second order interaction is 79.93) compared to the gross effect of season so that seasonal changes in the composition of the shoots are not obscured by changes in the intensity of the incident light. It has already been recorded[1] that the time trend of size of the bud relative to the topmost leaf remains the same whether the bush is plucked or not.

The influence of dose and kind of nitrogenous fertilisers in altering the proportions of the constituent parts of plucked shoots

is conditioned by changes in light intensity; conversely the influence of light intensity on the components of plucked shoots is conditioned by the kind and the dose of the nitrogenous fertilisers. The interactions of light intensity with the kind and dose of manure in altering the composition of plucked shoots is shown in Tables 4 and 5.

Table 4: Light intensity × Kind of manure × Component
Grammes dry weight per 190 gm. fresh shoots

Components	Mustard oil cake.			Sulphate of ammonia		
	100% light	50% light	40% light	100% light	50% light	40% light
1	5·98	5·21	5 36	5·55	5·67	5·26
2	1·11	0·96	0·97	1·03	1·07	0·97
3	10·13	9·17	9·37	9·07	9·52	9·13
4	3·15	2·88	2·77	2·75	2·90	2·74
5	10·05	10·11	10·30	9·45	9·98	10·12
6	2·23	2·33	2·32	2·20	2 15	2·22
7	0·77	1·04	0·98	1·11	1·02	1·18
8	0·14	0·20	0·19	0·19	0·20	0·21
9	4·25	4·44	4·51	5·96	4·57	4·86
10	3·38	2·90	2·56	3·92	2·79	3·19

Difference required for P=.05: 0.53 gm.

Table 5: Light intensity × Dose of manure × Component.
Grammes dry weight per 190 gm. fresh shoots

Components	75 lb N/acre			150 lb N/acre		
	100% light	50% light	40% light	100% light	50% light	40% light
1	5·61	5·79	5·53	5·92	5·09	5·09
2	1·05	1·07	0·98	1·09	0·96	0·95
3	9·61	9·75	9·54	9·59	8·94	8·96
4	3·01	2·96	2·81	2·90	2·82	2·69
5	9·88	9·80	10·44	9·63	10·29	9·98
6	2·18	2·11	2·25	2·26	2·36	2·28
7	0·96	0·86	1·02	0·93	1·21	1·14
8	0·17	0·16	0·18	0·16	0·24	0·22
9	5·10	4·19	4·59	5·11	4·83	4·79
10	3·30	2·93	2·44	4·01	2·76	3·31

Difference required for P=.05: 0.53 gm.

When oil cake is used as the source of nitrogen, the weight of the bud and the first leaf is significantly increased in full sun while the weight of the coarser components (5 to 9) tends to rise under the screens. With sulphate of ammonia, weight of the second leaf increases and that of the banjhies decreases under the screens. Again with the 150 lb. dose of nitrogen, weight of the bud and the first leaf is significantly reduced by the screens while no such effect is noticeable with the 75 lb. dose. With the lower dose of nitrogen the maximum proportion of the banjhies occurs in full sun whereas light intensity does not affect the weight of banjhies when the dose of nitrogen is higher.

The young parts of shoots have the greatest influence on the quality of made tea. Hence, those treatments which can increase the proportion of the young parts or reduce the weight of the banjhi shoots without reducing yield are of considerable practical interest.

Yield increase by moderate shade is not always associated with diminution in the proportion of the young parts or increase in the stem portions of plucked shoots, as is often believed to be the case. For instance, shade significantly reduced the proportion of the banjhi shoots in the early part of the year (June) without altering the proportion of the other components whereas no such effect was noticeable in July and October.

Recognition of different kinds of nitrogenous manures, apart from the nitrogen dosage, is inevitable in pratice. The effect of kind of manure on the young parts of shoots in sun and shade is shown in Table 6. The figures in Table 6 are abstracted from Table 4.

Table 6: Summated dry weight of constituents 1, 2, 3, & 4 in gms. per 190 gm. fresh shoots.

Manure / Light intensity	Oil cake	Ammonium sulphate.
100% (Full sun) ...	20·37	18·40
50% ..	18·22	19·16

This indicates a superiority of oil cake in full sun. The presumption is that in the presence of an adequate supply of nutrients, exemplified by oil cake, dry weight is greatest at high light intensities and is low under pronounced shade. It is low when bushes are manured with sulphate of ammonia. It would appear, therefore, that our soil is deficient in nutrients needed for the most rapid accumulation of dry matter in the young parts of shoots, some of which can be supplied by oil cake.

These data raise many interesting conjectures, among which we draw attention to the influence of light intensity and the kind of manure on the distribution of dry matter among parts of the shoot that are likely to determine the grades of made tea and their appearance.

Literature cited.

[1]Wight, W. *Phytomorphology*, 5(1), 1-11 (1955)

AGRICULTURAL BRANCH

S. K. Dutta—Senior Agriculturist

S. Basu—Assistant Agriculturist

K. N. Sharma—Agronomist

STAFF

Dr K. N. Sharma, Agronomist, joined this branch on the 17th July 1957. Messrs. D. J. Gray and W. J. Grice, Advisory Officers, completed their period of training on 30th April 1957. Mr. W. Hadfield, Advisory Officer (Designate), joined this branch on the 1st December 1957 for a period of training.

Mr. R. K. Sarma was appointed as a Field Trial Assistant in the Junior Non-Technical grade on 17th April 1957. Messrs. A. C. Barua and K. C. Thakur joined as Junior Technical Grade Assistants on the 1st May 1957. Mr. P. C. Barua joined as a Junior Technical Grade Assistant on the 16th November 1957.

RESEARCH AND EXPERIMENT

Introduction :

41 long and short term field experiments were in progress at Borbhetta during 1957. The Agricultural Experiments in Cachar, Dooars and Darjeeling numbering 34 were also taken over by this branch during 1957 and short reports on some of these experiments appear in the respective Advisory Branch reports.

4 long and short term experiments at Borbhetta were terminated during the year and 9 new experiments and trials were commenced. The main subjects of study and experimentation both at Borbhetta and in the districts were manuring, shade, pruning, cultivation and green crops. A number of demonstration plots and old experiments retained as demonstrations, were as usual, maintained. Either long term or short term results of some of these Borbhetta experiments are given in this report, and a list of the experiments is given as an appendix In

particular, Manurial Experiments have been reviewed in the present report. The following is a brief resume of some of the more important results in 1957.

Under Borbhetta conditions transplanting of tea plants is best done by lifting plants from the nursery with a ball of earth around the roots. It has also been demonstrated that the use of cattle manure or oilcake at the time of planting is most beneficial and that use of oilcake increases the percentage of mortalities when the transplanting is done without the ball of earth around the roots of the nursery plants. In a manuring experiment, it has been seen that application of urea depresses yield when applied in large doses. Effects of shade and manures on the size of plucked two and a bud shoots have been demonstrated. The good effects of nitrogen as sulphate of ammonia have once again been demonstrated. The effects of phosphate and potash on the yield of mature tea are still inconsistent and no marked responses have been noticed. These have also had no effect on the valuation of the made teas.

Strikingly improved growth of *Crotalaria anagyroides* due to the application of phosphate has been observed. Various green crops and shade tree species are under trial and it is considered that *Albizzia sumatrana* can be recommended for trial on a commercial scale as a long term shade tree. *Albizzia maranguensis* and *Albizzia richardiana* are also worth commercial trial as temporary shade trees.

N.P.K. Manuring of Mature Assam Tea—Expt. No. B.11-2 :

The experiment was started in 1954 on an Assam jat of tea planted $4\frac{1}{2}' \times 4\frac{1}{2}'$ triangular in 1928. *Albizzia odoratissima* was planted at 54 ft. $\times$ $31\frac{1}{2}$ft. spacing in 1949 for shade.

The experiment consists of two parts. The first part is a 3×3 factorial and completely orthogonal with blocks. This part is first split for three levels of nitrogen, 0, 40 and 80 lbs. per acre and then 9 combinations of phosphate and potash at 0, 40 and 80 lbs. per acre are imposed at random on each whole plot.

The second part of the experiment consists of 16 treatment combinations of phosphate 0, 20, 40 and and 80 lbs. and of potash,- 0, 20, 40 and and 80 lbs. per acre.

Direct Effects.— The overall effect of nitrogen was significant every year. With an increase in the level of nitrogen, there were significant increases in the yields of made tea. The results of the last four years are given in Tables 1 and 2. The increases obtained from nitrogen application were linear. The cumulative effect of nitrogen was also noticeable in the results of first three years. But last year, all yields were low because of the season. The yields from the no nitrogen plots were practically the same every year whereas there was a progressive increase in yields from the nitrogen plots in the first three years.

Table 1: Yields in mds. made tea per acre.

Year / Manure	1954 (from July to end of season)	1955	1956	1957
N_0	5·51	6·13	6·42	6·67
N_{40}	6·53	8·00	9·05	8·62
N_{80}	7·40	10·65	11·74	10·35
Significant Difference at 5% level	0·68	1·68	1·90	1·73

Table 2: Percentage increase due to nitrogen treatments.

Year / Manure	1954	1955	1956	1957
N_{40}	18	30	40	29
N_{80}	34	73	83	55

The overall effects of phosphate and potash were not significant except in 1955 when P_{80} gave a significantly higher yield

than P_0. This increase of 0.63 mds. of tea from the application of 80 lbs. P_2O_5 was not worth the amount of money spent on phosphatic fertilisers.

Table 3: Yield in mds. per acre during 1955.

Manure ...	P_0	P_{40}	P_{80}	S.D.
Yield ...	7.89	8·38	8·52	0·51
Increase over P_0 ...	...	0·49	0·63	
Price of the fertiliser per acre ...	Nil	Rs. 30·54	Rs. 61·08	

Interactions.— In 1954 N. P. K. and N. K. interactions showed significant results. N_{80} and P_{80} in absence of potash produced the highest yield, but the presence of K_{40} tended to decrease the yield and it was significant in presence of K_{80}. Also K_{80} in presence of N_{80} depressed the yield when compared to N_{80} K_0. The interactions were not significant in 1955 and 1956 results. In 1957 in the P. K. interaction, P_{80} in absence of potash produced higher yield, but the presence of K_{80} significantly reduced the yield.

Table 4: Yields in mds. per acre during 1957.

K / P	K_0	K_{40}	K_{80}
P_0	8·24	8·77	8·01
P_{40}	8·27	8·10	9·19
P_{80}	9·26	9·10	8·00
Sign. Diff. at 5% level		1·09	

Discussion.— It is evident from the results of the last four years of this experiment that nitrogen application to mature tea has increased the yield. The responses of nitrogen were similar to that obtained from the other N. P. K. experiments at Borbhetta on mature tea. With the increase in nitrogen from 40 lbs. to 80 lbs. a proportionate increase in yield has been obtained

every year. As regards the overall effects of phosphate and potash, no significant differences were obtained during these four years. Nothing consistent has been obtained from the N. P. K. interactions and it would be too early to draw any definite conclusions.

Characters of Made Teas.— 8 samples from all plots were manufactured by using Pizey rollers at fortnightly intervals from June to September 1957 and the teas were tasted by the Tocklai Taster. In the direct effects of nitrogen, phosphate and potash there was no significant difference in the quantity of tip, briskness, and valuation. The overall effect of phosphate showed significant differences in quality and strength of liquor. No phosphate was better than P_{40} whereas there was no marked difference between P_0 and P_{80} and also between P_{80} and P_{40} as regards quality. For strength of liquors P_{80} was significantly better than P_{40} but there was no difference between P_{80} and P_0 and also between P_0 and P_{40}.

Only the interaction of P and K produced significant results for quantity of tip. In presence of 40 lbs. K, P_{80} was significantly higher than P_{40} but there was no difference between P_0 and P_{80} as well as P_0 and P_{40}. It is too early to arrive at any definite conclusions about the effect of P and P & K on the cup characters.

N.P.K. Manures on Dark and Light Leaf Jats of Tea—Expt. No. B.7 :

The object of the experiment is to test the effect of N. P. & K. at different levels of Silbhetta light and dark leaf jats and the interactions that may follow. The tea was planted in 1935 and the experiment started on young tea in 1936. There were 72 plots of light leaf Assam jat and 72 plots of a Dark leaf Assam jat. Each plot consists of 96 bushes. Since 1947 the manurial treatments were sulphate of ammonia (40 lbs. and 120 lbs. N. per acre), superphosphate (0, 20 lbs. and 60 lbs. P_2O_5 per acre) and sulphate of potash (0, 20 lbs. and 60 lbs. K_2O per acre) and their combinations. The whole area was planted with *Albizzia chinensis* shade trees in March 1947. The last summary of results was published in the 1954 Annual Report. The present summary relates particularly to the results of the 4 year period 1954 to 1957.

Nitrogen.— The higher level of nitrogen (120 lbs. N. per acre) produced significantly higher yields than the lower level (40 lbs. N. per acre) in all the four years (*Table 5*). The same was true in every year since 1949 (Annual Report 1954).

Table 5: *Yield in maunds of made tea per acre under different levels of Nitrogen from 1954 to 1957.*

Year / Doses per acre	1954	1955	1956	1957
40 lbs. Nitrogen	13.36	14.86	16.38	14.74
120 lbs. Nitrogen	14.27	15.62	16.83	15.28
Significant Difference at 5% level	0.34	0.34	0.38	0.34
Percentage increase over 40 lbs. Nitrogen	6.81	5.11	2.75	3.66

Jat:— In every year the light leaf jat produced significantly higher yield than the dark leaf jat (*Table 6*). The same trend was noticed from 1949 to 1952.

Table 6: *Yields in maunds of made tea per acre of different jats from 1954 to 1957.*

Year / Jat	1954	1955	1956	1957
Light leaf	14.09	15.49	16.91	15.29
Dark leaf	13.54	15.00	16.30	14.74
Sig. Diff. at 5% level	0.34	0.34	0.38	0.38
Percentage increase over Dark leaf	4.06	3.27	3.74	3.73

Potash.— Application of 60 lbs. potash per acre significantly increased the yield over no potash from 1955 (*Table 7*). In 1955, 60 lbs. potash was also significantly higher than 20 lbs. potash. During these three years there was no significant difference in

yields between 20 lbs. potash and no potash whereas in 1954 all treatments failed to reach the level of significance.

Table 7: Yield in maunds of made tea per acre under different doses of Potash from 1954 to 1957.

Year / Doses per acre	1954	1955	1956	1957
K_0 – No manure ...	13·62	14·91	16·24	14·70
K_1 – 20 lbs. potash ...	13·93	15·20	16·58	14·96
K_2 – 60 lbs. potash ...	13·90	15·62	17·00	15·37
Significant Difference at 5% level	...	0·42	0·46	0·42

Phosphate.— Except in 1955, in all the four years, application of phosphate increased the yield significantly over no phosphate and there was no significant difference between the two doses (*Table 8*). During 1954 and 1956 application of 60 lbs. phosphate produced the highest yield whereas in 1957, 20 lbs. phosphate was the highest.

Table 8: Yield in maunds of made tea per acre under different doses of Phosphate from 1954 to 1957.

Year / Doses per acre	1954	1955	1956	1957
P_0 – No phosphate ...	13·38	15·08	16·18	14·56
P_1 – 20 lbs. phosphate ...	14·00	15·27	16·74	15·30
P_2 – 60 lbs, phosphate ...	14·08	15·38	16·90	15·17
Sig. Difference at 5% level	0·42	...	0·46	0 42

Phosphate and Potash Interaction.— The responses to all combinations of P and K are given in *Table 9*.

Table 9: Increase or Decrease in maunds of made teas per acre over absolute check ($P_0 K_0$) due to the individual or combined effects of different levels of Phosphate and Potash.

Treatments	Average 1941-46	Average 1941-53	1954	1955	1956	1957	Average 1941-57
$P_1 K_0$	0.78	1.28	0.42	−0.39	0.17	0 43	1.016
$P_2 K_0$	1.12	1.92	−0.23	0.24	0 58	0.41	1.527
$P_0 K_1$	0.32	−0.06	0.27	0 24	0.32	0.46	0.03
$P_1 K_1$	0.79	1.34	0.62	0.29	0.82	0.81	1.174
$P_2 K_1$	1.18	1.66	1.14	0.21	0.65	0.37	1.409
$P_0 K_2$	0.10	−0.02	0.63	0.12	0.25	−0.03	0.042
$P_1 K_2$	1.34	1.93	0.80	1.02	1.27	1.41	1.741
$P_2 K_2$	1.25	1.64	0.84	0.83	1.49	1.47	1.526

Phosphate alone even at 20 lbs. per acre, produced an average increase of 1.016 maunds of made tea per acre per year during the 17 years till 1957. By trebling level of phosphate to 60 lbs. per acre there was an extra increase of only (1.527-1.016) 0.511 maunds of made tea per acre. When potash alone was applied it had no beneficial effect on the crop (*Table 9*). In the presence of 20 lbs. phosphate increasing doses of potash increased the yield when compared with 20 lbs. phosphate alone whereas in the presence of 60 lbs. of phosphate, potash decreased the yield. The highest increase was obtained with an application of 20 lbs. of phosphate and 60 lbs. potash (*Table 9*), but this 18 years' average increase from $P_1 K_2$ was not economical when compared with $P_2 K_0$ (1. 741 - 1 527 = 0.214 mds.). Shade trees

were planted during 1947. The increases due to phosphate during 1941-46 i.e. before shade trees were planted were not so pronounced as they were during the period of 1946-53 (average figures 1941-53 in *Table 9*). Again during the period of 1954-57 the increases were not so high. This might be due to the deterioration in the health of the *Albizzia chinensis* shade trees due to attacks by Red Rust and Canker. The experiment showed that when there was a good shade from healthy plants it was economically beneficial to apply 60 lbs. of phosphate per acre to the tea.

Characters of Made Teas. – In 1957 large samples of green leaf from manurial plots $N_2P_0K_0$, $N_2P_2K_0$, $N_2P_0K_2$ and $N_2P_2K_2$ were manufactured on seven occasions and the made teas were tasted by the Tocklai Taster and a panel of Calcutta tasters. Tasters' numerical assessment of the quantity of tip, strength of liquors, quality, briskness and valuation were statistically analysed and in none of these attributes were the effects of manure found to be significant.

Effect of Phosphate and Potash Manuring—Expt. No. B.40:

The object of the experiment was to measure the effect of different combinations of phosphate and potash at four levels with and without shade on the yield of tea.

The area was planted with tea of Tingamira jat in 1922 at 4′—6″ triangular and the experiment was started in 1931. In 1941 *Albizzia chinesis* was planted to study the effect of 4 doses (0, 15, 30 and 60 lbs. per acre) of phosphoric acid and potash with a basic dose of 40 lbs. nitrogen per acre with and without shade.

Results of this experiment have been published up to 1953 in the Annual Report 1954. The results from 1954 to 1957 have been summarised below.

Shade.— Each year shade showed highly significant increase in yield over no shade, irrespective of the level and combination of manures. This was also true with the data of 1949 to 1953.

Table 10: Yield of made tea in mds. per acre.

Treatment \ Year	1954	1955	1956	1957
No shade	11·68	11·52	11·05	9·46
Shade	15·03	16·08	15·52	13·76
Sig. Diff. at 5% level	0·61	0·90	1·13	1·29
% increase over no shade	28·68	39·58	40·45	45·45

Phosphate.—In each of the four years, application of 60 lbs. P_2O_5 per acre significantly decreased the yield as compared to no phosphate. During 1954 and 1955, P_{15} produced the highest yield but it was not significantly higher than P_0 and P_{30}. In 1956 and 1957 all the doses of phosphate tended to decrease the yield but the differences were not significant between P_0, P_{15} and P_{30} whereas P_{60} significantly depressed the yield (*Table 11*).

Table 11: Yield in mds. made tea per acre in different levels of Phosphate.

Treatment \ Year	1954	1955	1956	1957	Average	% increase or decrease over no phosphate
P_0	13·56	14·06	13·76	12·14	13·38	—
P_{15}	13·70	14·21	13·67	11·81	13·35	−0·22
P_{30}	13·43	13·76	13·20	11·65	13·01	−2·76
P_{60}	12·73	13·18	12·51	10·84	12·32	−7·92
Sig. Diff. at 5% level	0·54	0·62	0·59	0·61	—	—

Potash.— It appeared that as the dose of potash increased, the yield also tended to increase. But the overall effect of potash failed to show any significant differences and in any case, the application would not be economic (*Table 12*).

Table 12: *Yield in mds. made tea per acre in different levels of Potash.*

Levels of Potash	1954	1955	1956	1957	Average
K_0	13.09	13.47	13.15	11.32	12.76
K_{15}	13.22	13.72	13.16	11.44	12.88
K_{30}	13.47	13.78	13 26	11 78	13.07
K_{60}	13.67	14.22	13.56	11.91	13.34

Shade x Phosphate.— Only in 1957 interaction of shade and phosphate produced significant results. Under no shade P_{60} and P_{30} significantly depressed the yield when compared to P_0. Under shade P_{30} only was significant over P_{60} but there was no significant difference between P_{30}, P_{15} and P_0. Data of Table 13 showed that under no shade phosphate application depressed the yield whereas there was some beneficial effect from small doses of phosphate under shade. It has been reported in Annual Report 1954 that phosphate application is beneficial to shade trees. There is a probability that application of phosphate under shade produces more beneficial effects on the shade trees than the tea itself.

Other interactions of potash failed to show any significant results.

Shade and Manuring—Expt. No. B.5:

The object of the experiment was to study the effect of three levels of nitrogen with and without phosphate and potash under shade and no shade. The area was planted up in November 1932 with one year old Deamoolie seedlings at 4 ft. square spacing. In April 1942, *Albizzia chinensis* (Sau) was

Table 13: Yield in mds. per acre under Shade X Phosphate.

YEAR	1954		1955		1956		1957		Average	
Shade / Phosphate	No Shade	Shade	No Shade	Shade	No Shade	Shade	No Shade	Shade	No Shade	Shade
P_0	11.98	15.15	12.23	16.49	11.80	15.72	10.49	13.79	11.62	15.29
P_{45}	12.16	15.23	12.52	15.58	11.47	15.88	9.64	13.98	11.45	15.17
P_{90}	11.57	15.29	10.41	15.79	10.86	15.54	9.16	14.14	10.50	15.19
P_{00}	11.02	14.41	9.62	15.14	10.07	14.95	8.55	13.14	9.82	14.41
Sig. Diff. (P=.05)	Not significant		Not significant		Not significant		0.87		—	

planted up and a 2 x 2 x 2 x 4 factorial experiment was started. 1st. and 2nd. order interactions were unconfounded, 3rd. order interactions were confounded in blocks having a total of 128 plots each with 96 bushes. The treatments were (A) Shade and no Shade, (B) No phosphate and 45 lbs. P_2O_5 per acre, (C) No potash and 45 lbs. K_2O per acre and (D) Nitrogen as sulphate of ammonia (i) no nitrogen, (ii) 30 lbs. nitrogen, (iii) 60 lbs. nitrogen and (iv) 90 lbs. nitrogen per acre.

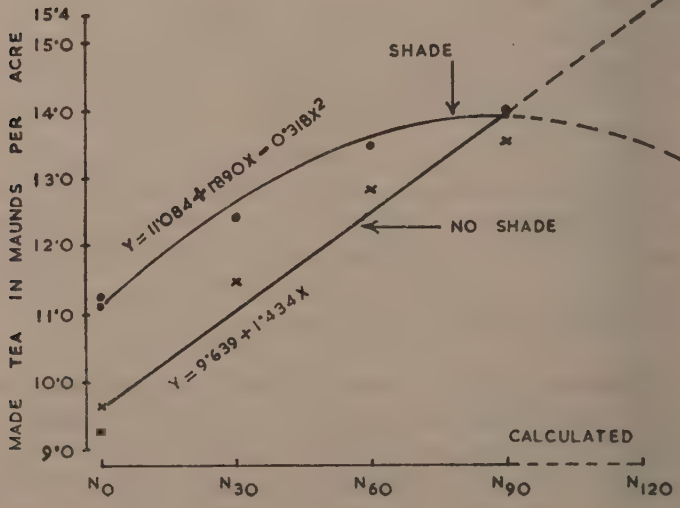
Shade.— From 1942 to 1945 the yields were higher under no shade than shade but since 1946 the yields under shade were significantly higher that no shade (*Table 14*). As the shade was planted in 1942 it was probably due to the shade trees getting established as the yields in these plots were lower than the plots which were not planted with trees.

Phosphate.— In the overall effect of phosphate there was no statistically significant difference between no phosphate and 45 lbs. phosphate per acre in the yields of last 16 years. But the application of 45 lbs. of phosphate per acre produced a depressing effect on the yields of mature tea. Since 1945 application of

45 lbs. phosphate under shade had significantly increased the yields whereas under no shade it had significantly depressed the yields (*Table 15*). The results of this experiment go to show that phosphate was beneficial only where the tea was under *Albizzia chinensis* shade trees. The same trend was also noticed in some other Borbhetta experiments.

Nitrogen (Overall Effect).— During 1942 and 1943 the differences between different nitrogen levels were not significant. From 1944 to 1956, the yield increased as the dose of nitrogen increased. The differences in yield from the different levels of nitrogen were significant from 1945 to 1951 whereas from 1952 to 1956 the differences between 90 lbs. nitrogen and 60 lbs. nitrogen per acre were not significant (*Table 16*). The responses due to levels of nitrogen under shade or without shade were almost the same. This lack of response to the higher dose of nitrogen may partly be attributed to the fact that the tea in absence of shade is gradually deteriorating in health and the tea under shade is also gradually giving lower yields because of the deterioration of the health of the ageing *Albizzia chinensis* shade trees. The observed graph of 16 years' average yield for different levels of nitrogen under shade and no shade had correctly fitted with the calculated graph (Graph No. 1). The calculated

GRAPH NO. 1



curve of yields under shade meets the curve of yield under no shade at 90 lbs. nitrogen level. At the same time under shade the yield does not increase if the level of nitrogen is increased from 90 lbs. to 120 lbs. and after 120 lbs. nitrogen, it has a tendency to go down, whereas the yield curve under no shade continues to rise as the dose of nitrogen is increased from 90 lbs. to 120 lbs. This shows that under shade the optimum dose of nitrogen for this tea can be 90 lbs. per acre whereas under no shade the optimum dose of nitrogen can be 120 lbs. nitrogen per acre or even more.

Phosphate and Potash Interaction.— There was no significant increase during all these 16 years from $P_0 K_{45}$, $P_{45} K_0$ and $P_{45} K_{45}$ over $P_0 K_0$. The average yearly increases or decreases in yield in mds. per acre due to these combinations of the manures over $P_0 K_0$ were—$P_0 K_{45} = + 0.03$, $P_{45} K_0 = - 0.20$ and $P_{45} K_{45} = + 0.16$. Hence, it can be said that the different combinations of phosphate and potash were neither economic nor beneficial under the conditions of this experiment.

Table 14: Yield in mds. made tea per acre from 1942 to 1957.

Year	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957
No Shade ...	11·91	11·93	8·10	11·05	10·84	12·62	13·74	14·30	13·43	10.99	13.20	10.83	11.82	11.28	12.05	10.58
Shade ...	11·92	11·83	8·09	10·87	11·26	13·32	14·84	15·30	14·86	12.21	15.13	12.93	13.37	13.18	13.90	11.94
Sig. Diff. at 5% level ...	...	...	0·32	0·34	0·38	0·69	0·22	0·75	0·44	0.52	0.72	0.44	0.29	0.33	0.37	0.50
% increase or decrease over no shade	0·084	−0·84	−0·12	−1·63	3·87	5·54	8·005	6·99	10·65	11 .10	14.62	19.39	13.11	16.84	15.35	12.85

Table 15: Increases or decreases in made tea in mds. per acre under shade and no shade in presence of 45 lbs. P_2O_5 per acre.

Increases or Decreases	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	Total of 16 years
Presence of P_2O_5 with-out shade	0.36	-0·04	-0·23	-0·71	-0·67	-0·90	-0·85	-0·69	-0·80	-0·42	-0·81	-1·08	-1·05	-0·73	-1·02	-0·79	-10·43
Presence of P_2O_5 under shade	0.30	0·46	0·56	0·50	0·52	0·99	0·81	1·20	0·81	0·71	0·94	0·76	0·42	0·48	0·15	0·55	10·16
Shade in the absence of Phosphate	0.40	-0·35	-0·40	-0·79	-0·18	-0·24	1·65	0·06	0·62	0·65	1·06	1·18	0·82	1·30	1·26	0·70	7·38
Shade in the presence of Phosphate	-0.02	0·15	0·39	0·42	1·01	1·65	0·12	1·95	2·23	1·78	2·81	3·02	2·29	2·51	2·43	2·04	24·78
Significant Difference at 5% level	—	—	0·46	0·48	0·52	0·72	0·73	0·89	0·85	0·71	0·98	0·75	0·85	0 83	0·81	0·69	—

Table 16: Increses of made tea in mds. per acre under different levels of Nitrogen over No nitrogen.

	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951.	1952	1953	1954	1955	1956	1957	Total of 16 years.
N_1—30 lbs. Nitrogen per acre	0.96	1.42	0.83	1.68	0.60	2.24	2.33	2.15	1.49	1.75	2.17	2.49	1.77	1.82	1.93	1.39	27.02
N_2—60 lb. Nitrogen per acre.	1.14	2.60	1.75	2.96	1.37	4.09	4.05	3.37	2.57	2.84	4.10	3.92	3.38	3.14	3.29	2.58	47.15
N_3—90 lb. Nitrogen per acre	0.83	2.94	2.06	3.66	2.11	5.30	5.43	4.74	3.82	3.71	4.34	4.46	3.93	3.32	3.30	2.51	56.46
Significant Difference at 5% level	...	...	0.46	0.48	0.52	0.72	0.73	0.89	0.85	0.71	0.96	0.75	0.85	0.83	0.81	0.69	...

Different Shade Tree Species and Effect of Phosphate and Potash —Expt. No. B.1A :

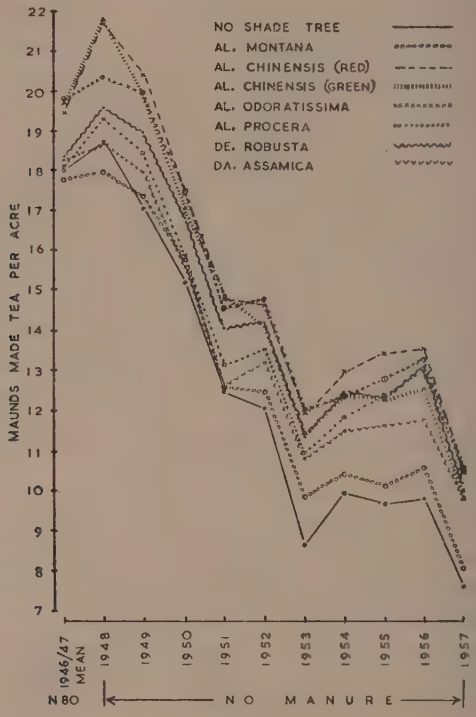
The object of the experiment was to study the effects of different shade tree species and the effect of phosphate and potash separately and in combination on the yield of tea. The area was planted in 1939 with Khorijan jat at 4½ ft. triangular spacing and the shade trees were planted in October 1941. The layout was split plot design splitting for manuring and then the shade tree species were randomised having four blocks with 128 plots each having 107 bushes. The manurial treatments per acre were (1) 40 lbs. potash, (2) 40 lbs. phosphate, (3) 40 lbs. of potash and 40 lbs. phosphate, (4) no manure. There were seven shade tree species and a check having no shade. (1) No shade tree, (2) *Aleurites montana*, (3) *Albizzia chinensis* (Red), (4) *Albizzia chinensis* (Green), (5) *Albizzia odoratissima*, (6) *Albizzia procera*, (7) *Derris robusta and* (8) *Dalbergia assamica*.

Results upto 1952 have already been reported in the 1953 Annual Report.

Manures.— Application of potash or phosphate or their combination failed to produce any significant effect on the yield of made tea. In order to study the effects of the shade trees only, application of nitrogen was stopped from 1948. The benefit of the nitrogen applied could be observed in the tea upto 1949 but afterwards there was a steep decline of yield under all the shade tree species upto 1952 (Graph No. 2). From 1952 the yield became rather stable except in 1957 where it showed a further decline but this was possibly due to the abnormal season. It has again been decided to apply 80 lbs. nitrogen per acre to all the plots from 1958 in order to observe the effect of nitrogen after a period of 10 years. (*See Graph No. 2 on page 94*)

Shade tree species.— As evident from Table 17 *Albizzia chinensis* (Red) and *Albizzia odoratissima* remained the more efficient trees. The same trend was also noticed from 1947 to 1952. The tea under *Derris robusta* also gave significantly higher yield and was reaching the level of the two above mentioned shade tree species. Among shade tree species *Aleurites montana* was not efficient and the yield under this shade tree was almost the same as under no shade. This was the

only non-leguminous non-nitrogen fixing tree used in the experiment. Among leguminous species Dalbergia assamica was



Graph No. 2

the poorest as regards its effect on the yield. The reason could be its leaflessness for nearly six months in the year, as the leaf starts to fall at the end of December and the trees do not come into leaf until about the end of June. From the graph it is evident that there have been three groups among the shade tree species as regards the yield of tea. From 1947 to 1952 the top group had both the *Albizzia chinensis* varieties (Red and Green) and *Albizzia odoratissima* and the bottom groups consisted of no shade tree, *Aleurites montana* and *Dalbergia assamica*. During this period there was a tendency for *Derris robusta* to go in the top group from the middle group—from 1952 the top group had the same 3 shade trees as in previous years but it included *Derris robusta* and the bottom group contained only no shade

tree and *Aleurites montana*. From 1955 *Albizzia procera* also joined the top group and by 1957 there were only two groups. All the leguminous shade trees were in the top group being significantly superior to the bottom group which had *Aleurites montana* and no shade tree. From this experiment it can be safely concluded that *Aleurites montana*, the only non-leguminous non-nitrogen fixing tree used, was not benefiting the tea at all. Among the leguminous shade tree species *Albizzia odoratissima* and *Derris robusta* were as efficient as *Albizzia chinensis*.

Table 17: *Yield in maunds of made tea per acre under different species of shade trees.*

Year / Species of shade trees	Average 1948 to 1952	1953	1954	1955	1956	1957	Average 1948 to 1957
No shade tree	15.10	8.66	9.95	9.68	9.78	7.6	12.12
Aleurites montana	15.22	9.84	10.42	10.15	10.58	8.2	12.53
Albizzia chinensis (Red)	17.78	11.90	12.96	13.40	13.54	10.5	15.12
Albizzia chinensis (Green)	17.54	11.45	12.33	12.24	12.51	9.8	14.60
Albizzia odoratissima	17.40	12.03	12.30	12.75	13.26	10.6	14.80
Albizzia procera	16.01	10.93	11.85	12.38	12.96	10.5	13.87
Derris robusta	16.72	11.35	12.40	12.32	13.08	10.0	14.28
Dalbergia assamica	15.60	10.81	11.50	11.63	11.76	9.8	13.35
Sig. diff. at 5% level		1.27	1.12	1.25	1.20	0.98	

Effect of Artificial Shade and Manure—Expt. No. B.8.1/3:

The object of the experiment is to find out the increase or decrease in yield brought about by artificial shade and kinds of nitrogenous manures with two levels of dressings and the interactions that may occur.

The area was planted in 1935 with Lotachapari jat at 4½ ft. triangular spacing and the experiment was started in 1952. The treatments were 4 types of nitrogenous manures (Mustard oilcake, Sulphate of Ammonia, Calcium Nitrate and Urea) with two levels of dressing. (150 lbs. nitrogen and 75 lbs. nitrogen per acre) under 3 light intensities (100%, 50% and 40% light). Layout was split plot designs having 4 randomised blocks with 96 plots each having 24 bushes.

Manure.— The effect of manure was highly significant. As in previous years, oilcake proved its superiority over urea and calcium nitrate. There was no significant difference between oilcake and sulphate of ammonia or between urea and calcium nitrate but sulphate of ammonia was significantly higher in yield than urea and calcium nitrate. As in previous years, the heavier dressing produced significantly higher yields over the lighter dressing. In the lower dressings, the different forms of manures failed to show any significant difference between themselves whereas in the higher dressing of 150 lbs. nitrogen per acre, yield from urea and calcium nitrate was significantly lower than sulphate of ammonia and oilcake.

Table 18: Yield in mds. made tea per acre under different forms of nitrogen manures and their different levels during 1957.

Forms / Doses per acre	Oilcake	Sulphate of Ammonia	Calcium Nitrate	Urea	Average
75 lbs. N	10·03	10·08	9·35	9 56	9·76
150 lbs. N	12·11	11·17	9·72	10 08	10·77
Average	11·07	10·63	9·54	9·82	

Significant Difference at 5% level for manures ... 0.60
Doses ... 0.42
Manures X Doses ... 0.84

By reference to page 69, Table 14, in the 1956 Annual Report it can be seen that during the period of last six years urea in the higher dose has depressed crop response in five of these years.

Observations on Shoot Growth.— Ten "two and a bud" shoots were taken from each plot on 12.9.57 and 13.9.57 to obtain shoot weight and area of shoot included in two leaves and a bud. Manures failed to show any significant effect on shoot weight. The effect of light also just missed the level of significance. This was in agreement with the results of 1957 crop analysis. But there was a trend which showed that 50% light intensity produced the highest shoot weight as well as crop yield (*Table 19*).

Table 19: Weight and total area of 10 Two and a Bud shoots and crop yield under different light intensities in 1957.

Light / Yield	40%	50%	100%	Sig. Diff. (P=·05)
Shoot weight in grams	216·3	226·3	189·0	Not significant
Crop yield of made tea in mds.	10·41	11·13	9·26	Not significant
Shoot area in sq. cm.	557·06	577·10	458·23	87·27

Shoot area including leaf.— The effect of light was only significant in leaf area. Both 50% and 40% light produced significantly higher leaf area than 100% light (*Table 19*). The correlation was calculated for crop yield vs. shoot area and produced a significant positive correlation in respect of light intensity and doses of manure. The 'r' for doses of manure treatment was complete and highly significant. (*Table 20*). The correlation coefficient for pruning weights vs. shoot area, for doses of manure was complete positive and highly significant.

Table 20: *Correlation coefficients between crop yield vs. shoot area and pruning weights vs. shoot area under different treatments.*

Treatment	Crop vs. shoot area – 'r'	Pruning weights vs. shoot area – 'r'
Light	0·97*	0·28
Manure	0·002	–0·02
Dose of manure	1·00**	1·00**
Light X Dose	–0·55	0·96*
Light X Manure	0·52	0·48
Manure X Dose	–0·10	–0·73
Light X Manure X Dose	0·33	0·87*

It was also evident that as the dose of nitrogen was increased from 75 lbs. nitrogen to 150 lbs. nitrogen per acre, the area and weight of plucked shoots (two and a bud), pruning weights, annual crop yield and calculated number of shoots also increased (*Table 21*).

Table 21: *Area and weight of 480 plucked shoots, Pruning weight, Annual Crop yield and Calculated number of shoots from Annual crop yield under different doses of Nitrogen—1957.*

Dose of nitrogen in lbs. per acre	Area of shoots in sq. cms.	Weight of 480 shoots in gms.	Pruning Weights in kgs.	Annual crop yield in mds. per acre	Calculated no. of shoots from the annual crop yield
75	784·39	309·9	727	9·26	11,62,839
150	808·00	321·9	816	10·77	12,35,776

Under different light intensities wherever there was an increase in crop yield there was also an increase in area and weight of plucked shoots, but the calculated number of shoots from the annual yield did not show the same trend.

Table 22: Area and weight of 320 plucked shoots, Annual crop yield and Calculated number of shoots from the Annual crop yield under different light intensities.

Light Intensity	Area of shoots in cm.	Weight of shoots in gms.	Annual crop yield in mds. per acre	Calculated no. of shoots from the annual crop yield
100%	458·23	189·0	9·26	8,04,233
50%	577·10	226 3	11·13	8,08,496
40%	557·06	216·3	10·41	7,91,111

There was also a positive significant correlation coefficient for pruning weights vs. shoot area in Light x Dose and Light x Manure x Dose interactions, which meant that wherever there was an increase in shoot area, pruning weights also increased.

Effect of Manures on Carrot and Bheti Planting—Expt. No. B.49/3 :

The object of the experiment was to investigate the effect of type of manure (cattle manure, oilcake and no manure) applied at the time of transplanting on Carrot (i.e. young plants without a ball of earth around the roots) and Bheti (i.e. young plants with a ball of earth around the roots) planting of tea seedlings. In a few instances, it was noticed that when bheti was damaged at the time of transplanting with oilcake, the mortality in young tea was increased. In order to ascertain this the present experiment was started and instead of artificially damaging the bheti, carrot planting was adopted.

Being a short term experiment, one year old Betjan seedlings were transplanted in early November 1956 at 2 ft. $\times$ 2 ft. square spacing. The treatments were 10 lbs. cattle manure, 12 ozs. oilcake and no manure with two methods of planting *viz.* Bheti and Carrot planting. The experiment had 4 randomised blocks with 24 plots each having 20 plants.

Comparing the type of planting, Bheti planting had more survivors, higher weight and volume of roots and larger amount of shoot growth as compared to Carrot planting. These results were statistically significant.

Table 23: Number of Survivors, Average weight and Volume of roots and Average pruning weights under. Carrot and Bheti planting

Type of planting	Number of Survivors	Weight of roots in gm.	Volume of roots in c. c. s.	Pruning weight in grams
Carrot	78	20·634	13,998	34,357
Bheti	238	47·248	44,980	1,14,077
Significant Difference (P=.05)	25	5,729	7,718	29,347

In Bheti planting, there was no significant difference between cattle manure, oilcake and Check as regards mortality. In the case of Carrot planting, as regards mortality, there was no significant difference between Check and cattle manure, but application of oilcake significantly increased the number of mortalities (*Table 24*).

Table 24: Average number of survivors per plot under different manures and method of planting.

Manures / Planting	Cattle manure	Oilcake	Check	Average	Significant Difference
Carrot	8.8	2.0	8.8	6.5	2·1
Bheti	20.0	19.8	19.8	19.8	
Average	14.4	10.9	14.3		
Significant Difference at 5% level		2.5			

Different manures failed to show any significant difference as regards weight and volume of roots in Carrot planting. In Bheti planting cattle manure recorded significantly the highest volume of roots and Check the lowest while for weight of roots

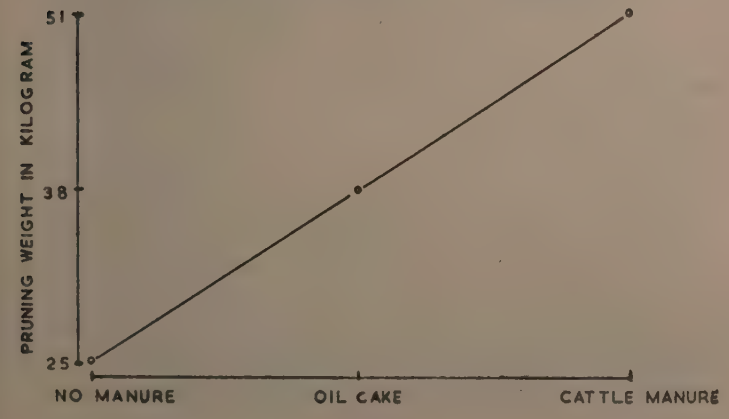
cattle manure was significant over both oilcake and Check, but there was no difference between oilcake and no manure (*Table 25*).

Table 25: *Average weight and volume of roots and average pruning weights under Bheti planting in different manures.*

Manures	Weight of roots in gms.	Volume of roots in c.c.s.	Pruning weight in.gms.
Cattle manure	19,230.5	19,631.6	51,097.53
Oilcake	15,509.0	15,084.2	38,040.22
Check-No manure	12,509.0	10,264.2	24,940.22
Significant Difference at 5% level	4,677.78	6,300.5	Not significant

In Bheti planting cattle manure produced the highest pruning weight and no manure the lowest, but the differences were not statistically significant (*Table 25*). As evident from Graph No. 3, there was a linear increase in shoot growth as measured by pruning weight from Check to oilcake and oil cake to cattle manure.

Graph No. 3: *Showing the effects of different manures on pruning weight under Bheti planting*



Under the conditions of the experiment Bheti planting was far superior to Carrot planting and in planting with bheties cattle manure was most beneficial for both shoot and root growth. It has also been seen that use of oilcake increases the number of mortalities when planting is done without bheties. Oilcake, on the whole, is better than no manure.

Mechanical Harvesting—Expt. No. B.6.2 :

The trial of the mechanical harvester was continued during 1957 in the same area of tea planted in 1935 at 4 ft. × 4 ft. square spacing, with some modifications in the treatments.

The treatments were as follows:—

A.—Hand pruned by leaving $\frac{1}{2}''$ of new wood and cleaned out by knife.
Hand plucked at 8 inches to the janam on a 7 day round.

B.—Mechanically pruned by leaving $\frac{1}{2}''$ of new wood and cleaned out by knife. Mechanically harvested on a 7 day round at 8″ above the pruning level, but with occasional rises by $\frac{1}{2}''$ from September.

C.—Mechanically pruned by leaving $\frac{1}{2}''$ of new wood and cleaned out by knife. Mechanically harvested on a 7 day round at 4″ above the pruning level till the middle of the 2nd flush and then raising by $\frac{1}{4}''$ on each round of plucking.

Yield figures of total leaf plucked are as follows:—

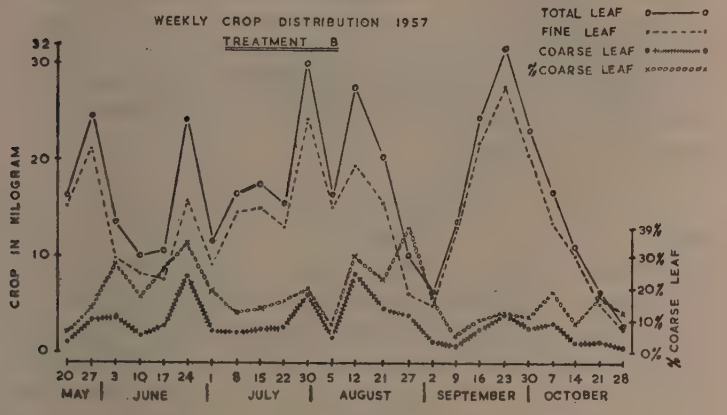
Table 26: Yield in mds. made tea per acre
(Not adjusted for unmanufacturable leaf.)

Hand plucking A	Mechanical harvesting B	Mechanical harvesting C
10·99	8·31	9·78

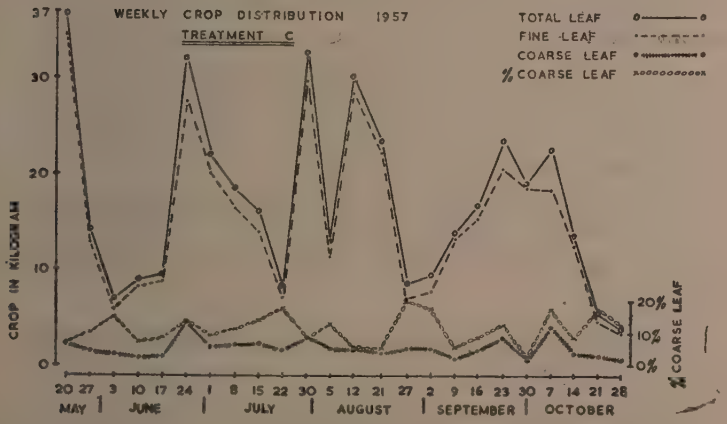
Difference required for significance at 5% level = 1.59 mds.

It is seen that Treatment C has not yielded significantly lower than Treatment A (hand plucking). Treatment B, where the tea was mechanically harvested at 8″ above the pruning level with no regular rises in each plucking round, yielded significantly lower than the hand plucked Treatment A.

There was a certain amount of unmanufacturable course leaf in the mechanically harvested treatments and these were separated after each round of plucking by the Senior Resident Engineer and these are shown in Graph Nos. 4 and 5.


WEEKLY CROP DISTRIBUTION 1957
TREATMENT B
TOTAL LEAF
FINE LEAF
COARSE LEAF
%COARSE LEAF
CROP IN KILOGRAM
% COARSE LEAF
20 27 3 10 17 24 1 8 15 22 30 5 12 21 27 2 9 16 23 30 7 14 21 28
MAY | JUNE | JULY | AUGUST | SEPTEMBER | OCTOBER

Graph No. 4


WEEKLY CROP DISTRIBUTION 1957
TREATMENT C
TOTAL LEAF
FINE LEAF
COARSE LEAF
%COARSE LEAF
CROP IN KILOGRAM
% COARSE LEAF
20 27 3 10 17 24 1 8 15 22 30 5 12 21 27 2 9 16 23 30 7 14 21 28
MAY | JUNE | JULY | AUGUST | SEPTEMBER | OCTOBER

Graph No. 5

From the results of 1957, it is quite apparent that mechanical harvesting at the same level is not desirable.

Mechanical pruning has not produced any apparent detrimental effect.

Manuring of Green Crop—Expt. No. B.103 :

The object of the experiment was to study the effect of different levels of phosphate, potash and calcium and their combinations when applied to a green crop on the growth of green crop and subsequently the residual effects on the growth of young tea. The treatments were,—three levels of phosphate as superphosphate (0, 40 lbs. and 80 lbs. P_2O_5 per acre), three levels of potash as sulphate of potash (0, 40 lbs. and 80 lbs. K_2O per acre) and two levels of calcium as slacked lime (0 and 4 mds. lime per acre).

In each sub plot four alternate rows of green crop were uprooted in February 1958 and 4 rows of tea are to be planted in their places in April 1958 to study the residual effect. There are 3 blocks of 18 plots, each plot having 7 rows of green crop. *Crotalaria anagyroides* was planted in the last week of April 1957 at $2\frac{1}{2}$ ft. apart. Slaked lime was applied 3 weeks before sowing of green crop whereas superphosphate and sulphate of potash were applied only one week before.

The following observations were made on the *Crotalaria anagyroides*:—

(1) Height of plants before the first lopping.

(2) Shoot and root weights of plant samples drawn in the last week of July.

(3) Weight of loppings at 3ft. in the first week of August.

(4) Plant samples drawn in the last week of November 1957.

(5) Weight of seeds collected in the 3rd week of January. 1958.

(6) Weight of loppings of 3 rows at $3\frac{1}{2}$ ft. and total weight of shoots of 4 rows cut at ground level during February 1958 where tea was to be transplanted in April, 1958.

(7) Weight of total green matter added from August, 1957 to February, 1958.

Height of Plants.— The effect of phosphate was highly significant while that of potash and calcium was not significant at 5% level of significance. There was a significantly linear increase over no phosphate with both 40 lbs. and 80 lbs. of phosphate per acre (*Table 27*).

Table 27:

Treatments	Mean height in inches	Weight of shoot in gm.	Weight of roots in gm.	Weight of loppings in kg.
P_0—No phosphate	20·6	1596	204	15·24
P_1—40 lbs. P_2O_5 per acre	42·0	3586	484	226·45
P_2—80 lbs. P_2O_5 per acre	46·9	6028	764	400·70
Sig. Diff. (P=·05)	5·0	1606	229	81·22

Shoot and Root weight at the age of 3 months.— Both the shoot and root weights of the green crop plants increased with the increase of phosphate levels. The differences in increase were strongly linear and highly significant (*Table 27*). The overall effects of potash and calcium on the plant growth characters failed to reach the level of significance. The interaction of Ca × P × K was significant for shoot and root weights. $Ca_1P_2K_2$ produced the highest shoot weight closely followed by $Ca_0P_2K_1$, the difference between the two treatments was not significant whereas $Ca_0P_2K_1$ produced the highest weight of roots.

Weight of loppings at 3 ft. after 3 months of growth.— Increasing doses of phosphate significantly increased the lopping weights and the response was strongly linear (*Table 27*). Application of lime had also significantly increased the weights whereas the effect of potash was not significant.

Among the interactions, calcium × phosphate and phosphate × potash were significant. The highest weights were in Ca_1, P_2 and K_1 P_2 respectively.

Shoot and Root weights at the age of 7 months.— Only the effects of different levels of phosphate were significant for shoot and root weights of plants. For weight of shoots 40 lbs. and 80 lbs. P_2O_5 were significantly higher than no phosphate but there was no significant difference between the two doses. For weights of roots, only 80 lbs. P_2O_5 produced significantly higher response over no phosphate (*Table 28*).

Table 28: Weight of shoots and roots of 7 month old Crotalaria anagyroides plants under different levels of phosphate.

	P_0	P_1	P_2	Sig. Diff. (P = ·05)
Weights of shoot in gms ...	21,574	34,039	37,144	7,748
Weight of roots in gms ...	1,812	2,352	2,845	617

Weight of Seeds.— There was no significant difference in the weight of seed harvested from the two doses of phosphate but both produced significantly higher yields than no phosphate. The effect of the P × K interaction was significant. P_{80} K_{40} produced the highest yield of seeds and was significantly higher than all combinations except P_{40} K_0 (*Table 29*).

Table 29: Weight of seeds in ounces from different levels and combinations of Phosphate and Potash

Phosphate \ Potash	K_0	K_1	K_2	Total
P_0	135	147	193	475
P_1	295	253	268	816
P_2	248	329	262	839
Total ...	678	729	723	2130

Significant Difference at 5% for the total of P = 101
,, ,, at 5% ,, ,, total of P × K = 59

Weight of Loppings.— Only different doses of phosphate produced highly significant effect on lopping weights of 3 rows cut at 3½ ft above ground and 4 rows cut at ground level. The increasing doses of phosphate increased the green matter.

Table 30: *Lopping weights of green crop under different levels of phosphate*

	P_0	P_1	P_2	Sig. Diff. at 5% level
Weight of the loppings at the age of 7 months in lbs.	3501	6348	7682	730
Total green matter lopped in lbs.	3534	6847	8562	843

Higher doses of phosphate also significantly increased the weight of total green crop cut during the season and applied in the field (*Table 30*).

Discussion.— The application of superphosphate had a pronounced effect on the growth of green crop *Crotalaria anagyroides*. As the level increased from 40 lbs. to 80 lbs. P_2O_5 per acre, the growth also increased. By the time the plants were three months old, increasing doses of superphosphate increased the height of plants, shoot and root weight of green crop and lopping weights when cut at 3 ft. height. At this age, application of calcium as well as the interaction of calcium and phosphate and of phosphate and potash produced significant results in weight of loppings whereas the overall effect of potash failed to show any significant effect throughout. At maturity both calcium and potash failed to show any marked effect on the vegetative growth. Phosphate maintained its superiority and the higher dose was beneficial for shoot and root growth. It is evident under the conditions of this experiment that when *Crotalaria anagyroides* is sown as a green crop, application of superphosphate alone at the rate of 80 lbs. P_2O_5 per acre will be beneficial (*i.e.*, 1 lb. of superphosphate drilled in 40 ft. row of green crop). Whereas if seeds are also required from the

green crop the mixture of 80 lbs. P_2O_5 per acre and 40 lbs. K_2O per acre will prove more productive. It has already been reported (Annual Report 1953) that a heavy dose of phosphate per acre as superphosphate alone produced significantly better results in the health and growth of leguminous shade trees. The same is true with the leguminous green crop *Crotalaria anagyroides* that 80 lbs. of phosphate as superphosphate is significantly beneficial.

Manuring of Bamboo—Expt. No. B. 9A :

The trial was started in July 1953 on young bamboo plants planted early in 1954. There are 4 treatments and five replications *i.e.*, 20 plots in all, each of which represents a bamboo clump. The preliminary observations on height and number of tillers of each clump were taken in early July, 1955. The fertiliser mixture was applied in a circle of 10 feet diameter. The treatments are shown in *Table 31.*

Table 31: Manuring of Bamboo—Treatments.

Treatments	Ammonium sulphate in lbs.		Superphosphate in lb.		Potassium sulphate in lb.		Total in lbs.		Ratio of N. P. K.		
	1955-56	1957	1955-56	1957	1955-56	1957	1955-56	1957	N	P	K
A	1⅓	3	⅛	1	⅛	1	2.0	5	4	1	1
B	1⅛	3	—	—	⅛	1	1⅔	9	4	0	1
C	1⅛	3	⅛	1	—	—	1⅔	4	4	1	0
D (Check)	—	—	—	—	—	—	—	—	—	—	—

Height.— Treatment C (NP) gave the best results in all the 3 years In 1956 this treatment significantly increased the height over Treatments A (NPK) and D (no manure) and during 1957 it was significantly better only over Treatment D (Check).

Table 32: Mean adjusted height and number of tillers.

Treatments	Mean adjusted height in feet			Mean adjusted number of tillers		
	1955	1956	1957	1955	1956	1957
A (NPK)	17.4	24.7	40.8	3.6	7.2	14.4
B (NK)	17.6	29.6	40.5	3.2	8.0	15.0
C (NP)	20.4	31.4	42.5	4.6	9.8	19.2
D (Check)	15.3	20.9	32.2	2.8	5.2	10.2
Sig. Diff. at 5% level	3.26	5.33	7.6	—	2.78	5.1
Order of Effect	C.B.A.D.	C.B.A.D.	C.A.B.D.	C.A.B.D.	C.B.A.D.	C.B.A.D.

Table 33: Percentage of increase in height and number of tillers due to N.P.K. manuring over no manure.

Treatments	% increase in height			% increase in no. of tillers.		
	1955	1956	1957	1955	1956	1957
A (NPK)	13.5	18.3	26.7	28.6	38.4	41.2
B (NK)	14.6	41.8	25.8	14.3	54.0	47.1
C (NP)	33.0	50.4	32.0	64.3	88.4	88.2

Number of tillers per clump.— Treatment C (NP) proved superior to other mixtures and check and significantly produced the largest number of shoots during 1956 and 1957 as compared to Treatment D (Check). From the tables it is clear that a complete mixture of N.P.K. actually depressed the growth as both NP and NK showed better results, particularly the former. Hence it can be concluded that under the experimental condi-

tions a mixture of ammonium sulphate and superphosphate in the ratio of 4: 1 increases the growth and development of young bamboos.

ADVISORY

Correspondence.— 201 letters were written by this branch in answer to queries on technical matters.

Touring.— The Senior Agriculturist visited 12 gardens in South India and 39 gardens in Assam, Dooars and Darjeeling. The Assistant Agriculturist visited 3 gardens.

Meetings.— The Senior Agriculturist attended the Annual Scientific Conference of the United Planters' Association of South India on 28th March, 1957.

Lectures.— The Senior Agriculturist delivered one address on "Cultural Practices in relation to Environment" at the 14th Annual Conference in November, 1957.

Courses.— The Senior Agriculturist ran two lecture courses on Vegetative Propagation in May, 1957. Two field assistants from member gardens were given training in Vegetative Propagation work. Mr. L. Moorlie, Agricultural Officer, Mauritius, was in training from 1st August to 3rd December, 1957.

Publications.— The following Tea Encyclopaedia Serials were published by the Senior Agriculturist:—

Serial No. 115 ... N.P.K. MANURING OF TEA SEED NURSERIES.

Serial No. 116 ... UPROOTING OF TEA.
—jointly with the Assistant Research Engineer.

Serial No. 53/2 ... MEDIUM PRUNING.
—jointly with the Senior Advisory Officer, Assam.

Serial No. 118 ... VEGETATIVE PROPAGATION.

The following was published in "Assam Review and Tea News", August 1957 and in "Tea Trade and Industry", Vol. VI, No. 6, June 1957:—

"EXPERIMENTS ON THE SPACING AND ARRANGEMENT OF TEA".

The following were published in the "Two and a Bud":—

Vol. IV, No. 1 ... EXPERIMENTS ON THE SPACING AND ARRANGEMENT OF TEA.

Vol. IV, No. 2 ... UREA AND AMMONIUM SULPHATE NITRATE.
—jointly with the Director and the Senior Physical Chemist.

Vol. IV, No. 3 ... CHOICE OF GREEN CROPS IN TEA.

Vol. IV, No. 4 ... CULTURAL PRACTICES IN RELATION TO ENVIRONMENT.

BORBHETTA EXPERIMENTAL ESTATE REPORT

Labour.— The average daily attendance during the year was 393.

Labour relations have been quite satisfactory during the year of report.

Crop Yield.— The total yield of green leaf during the year compared with that of 1956 was as follows:—

1956	...	...	2,54,590 lbs.
1957	...	...	2,49,403 lbs.

Of the 1957 crop 2,24,270 lbs. were sold to Messrs. Jorehaut Tea Co., Ltd. General plucking was stopped from the 22nd November 1957.

Building.— The following were built:—

(a) 14 pucca labour quarters.

(b) One godown.

(c) The Manager's quarter has been re-roofed.

(d) The Office building has been re-roofed.

(e) Water supply arrangements laid on for the office, dispensary and staff quarters etc.

Lands.— $3\frac{3}{4}$ acres of land were purchased during 1957. This brings the total of new lands purchased since 1955 to nearly $27\frac{1}{2}$ acres. Land position still remains acute.

APPENDIX

List of Experiments conducted by Agricultural Branch

Long Term Experiments:

Serial No.	Subject of Experiment	Area No.
1.	N.P.K. Manuring of Mature Tea	11/2
2.	N.P.K. Manuring of Mature Tea with six combinations in divided doses	43
3.	N.P.K. Manuring on Light and Dark Leaf Jats of tea	7
4.	N.P.K. Manuring on Young Asssam and China Jats	25/27
5.	N.P.K. Manuring of Tea Seed Bari	4/1
6.	Trial of New Shade Trees (12 species)	101
7.	Trial of New Shade Trees (16 species & No shade)	102
8.	Trial of New Shade Trees (7 species & No shade)	32.2
9.	Species of Shade Trees and P.K. Manuring ...	1A
10.	Shade and N.P.K. Manuring	5
11.	Shade and P.K. Manuring	40
12.	Density of Shade (with closeness of shade trees) in relation to Nitrogen Manuring	2A

Serial No.	Subject of Experiment	Area No.
13.	Density of Shade (3 light intensities) in relation to difference doses and forms of nitrogenous manures ...	8.1/3
14.	Relationship of Jat, Shade and Nitrogen ...	45/47
15.	Periodicity of Shade	34.1/3
16.	Annual vs. Biennial Prune	5A
17.	Pruning Cycles	22.1
18.	Height of Plucking	20
19.	Spacing of Tea (5 spacings)	29.4
20.	Spacing of Tea (2 spacings, 2 clones and 4 levels of manure)	12.2
21.	Spacing in planting of Two Clones with doses of Nitrogen	104
22.	Agricultural Trials of Clones and Clonal Progenies with different manures	33.2A

Short Term Experiments :

1.	Types of Nitrogenous Fertiliser ...	28.1	5 years
2.	Type of Phosphatic Fertiliser on Mature Tea	15/1	1 year
3.	Type of Phosphatic Fertiliser on Young Tea	44A	5 years
4.	Trial with Urea	15/2	3 „
5.	Time of Pruning	33.2C	2 „
6.	Debudding and Skiffing in Nursery ...	51/1	2 „
7.	Time and Method of Cleaning Out ...	43A	3 „
8.	Mechanical Plucking	6.2	4 „
9.	Method of Planting and Manuring ...	49A	1 year
10.	Introduction of new Shade Trees ...	45 & 100	3 years
11.	Introduction of new Green Crops ...	24 & 26	3 „
12.	Manuring of Green Crop ...	103	1 year
13.	Green Manuring on Eelworm Population	43D.1/2	1 „

Demonstration Plots :

Pruning of Tea in Nurseries	...	19A/2
Time and Method of Cleaning out		41
Method and Time of Planting out ...	...	9C/14
Type and Amount of Cultivation ...	...	25A
Type and Amount of Cultivation ...	...	34.1
Pruning Severity and Cleaning out ...	...	28

PLANT PATHOLOGICAL BRANCH—ENTOMOLOGICAL SECTION

G. M. DAS—Senior Entomologist.

STAFF

Mr. H. N. Deb, M.Sc., joined the branch as Senior Technical Assistant; Messrs. B. C. Rabha, M. R. Ghosh, A. K. Das, P. K. Bora, and N. Kakati joined as Survey Assistants. Messrs. U. C. Bania and P. K. Bora resigned in October and November respectively.

RESEARCH AND EXPERIMENT

Looper caterpillar (Biston suppressaria Guen.):

A field trial at Rangajan T.E. was carried out with Malathion, DDT, Endrin and Toxaphene against Looper caterpillar, using 80 gallons of spray per acre, applied by means of low volume sprayers.

Table 1: Rangajan—Trial A

Treatments	Looper population per 5 bush a week after treatment (mean of 3 replicates)	Percent reduction over check.
A. DDT 50% W. P. at 1 lb. in 20 gallons water	49·3	6.5
B. DDT 16% E. C. at 1 in 320 parts water	37·7	28.5
C. Endrin 19·5% E. C. at 1 in 1000 parts water	5·3	90.0
D. Malathion 50% E. C. at 1 in 500 parts water	44·0	16.5
E. Toxaphene 50% E. C. at 1 in 500 parts water	33.7	34.2
F. Check (Untreated)	52·7	...
Significant difference at 5% level ...	22·9	...

Endrin proved to be highly effective inspite of 3.9 cm. rainfall within 24 hours after treatment while none of the other pesticides gave significant control of the pest.

Another trial was carried out a week later in the same estate with similar treatments, where Endrin was found to give about 79% reduction in the population over check within 48 hours of treatment, while all other pesticidal treatments showed significant control, but they were inferior to Endrin (Table 2). Observations could not be continued for unforeseen reasons.

Table 2: Rangajan—Trial B.

Treatments	Looper population per 5 bushes 48 hrs. after treatment (Mean of 3 replicates)	Percent reduction over check.
A. DDT 50% W. P. at 1 lb. in 20 gallons water.	36.0	44.87
B. DDT 16% E. C. at 1 in 320 parts water	36.3	44.41
C. Endrin 19.5% E. C. at 1 in 1000 parts water	14.0	78.56
D. Malathion 50% E. C. at 1 in 500 parts water	45.0	31.09
E. Toxaphene 50% E. C. at 1 in 500 parts water.	34.3	47.47
F. Check (untreated)	65.3	...
Significant difference at 5% level ...	15.3	...

Jassid (Empoasca flavescence Dist.):

Studies on the life-history, natural enemies, and susceptibility of different clones to Jassid attack were undertaken.

The nymph undergoes five moults before becoming an adult. The duration of nymphal stages as observed in the months of January to July is given in the following table.

Table 3: Duration of nymphal stages of the Jassid.

Months	1st instar stage	2nd instar stage	3rd instar stage	4th instar stage	5th instar stage
January	3-4 days	2-4 days	3-4 days	3-5 days	4-6 days
February	2-4 ,,	2-4 ,,	2-4 ,,	2-5 ,,	3-6 ,,
March	2-3 ,,	1-3 ,,	1-3 ,,	2-5 ,,	3-5 ,,
April	2-4 ,,	1-3 ,,	1-3 ,,	1-4 ,,	3-5 ,,
May	1-2 ,,	1-2 ,,	1-2 ,,	1-3 ,,	2-4 ,,
June	1-2 ,,	1-2 ,,	1-2 ,,	1-3 ,,	2-4 ,,
July	1-2 ,,	1-2 ,,	1-2 ,,	1-3 ,,	2-3 ,,

Natural enemies.— A Hymenopterous parasite (Drynidae) has been recorded for the first time at Tocklai, attacking later nymphal instars. The parasitized Jassid can be recognized by the presence of a sac-like projection on the dorsolateral side of the abdomen. The sac appears to be greenish blue, the colour being due to the colour of the parasite larva lodged inside in the form of 'U'. Studies on the life-history of the parasite are continuing. No egg has yet been found. The egg is probably laid inside the body of the pest between the two anterior abdominal segments beneath one of the wing lobes. The parasitised Jassid can be recognised later by the presence of a larval sac on the dorsal surface of the abdomen. When full-grown, the larva comes out of the sac and searches for a suitable place for pupation. The host dies during the later stage of the larva, or shortly after its emergence from its body. In the case where the host dies before the larva becomes full-grown, the latter may also die within the larval sac. The degree of parasitization was estimated at Tocklai from February to July and results are given below:

Table 4: Degree of Parasitization.

Months	Total No. of Jassids.	No. of parasitized Jassids	Percent parasitization
February ...	190	21	11
March ...	279	16	5·7
April ...	331	12	3·6
May ...	180	3	1·6
June ...	84	1	1·2
July ...	184	6	3 2

The adults of the family Drynidae are said to be predacious and a greater mortality of pest population is effected in this way than by parasitization (Clausen, 1940).

Clonal susceptibility to Jassid attack.— The intensity of Jassid attack was estimated in Tocklai clonal plots during May and

the results are presented in the adjoining tables.

Table 5: Clonal Susceptibility—A.

Clone No.	Average intensity of attack per bush (mean of five replicates).
16/10/8 ...	1·6
1/3/14 ...	2·0
16/8/7 ...	2·1
1/7/1 ...	1·2
16/8/17 ...	2.2
16/12/15 ...	1·5
Significant difference at 5% level ...	0·3

Table 6: Clonal Susceptibility—B.

Clone No.	Average intensity of attack per bush (mean of 3 replicates).
14/4/1 ...	1·7
19/32/12 ...	1·3
19/29/12 ...	1·3
19/22/4 ...	1·2
19/13/13 ...	0·46
19/27/9 ...	1·6
19/29/7 ...	1·5
19/11/11 ...	1·0
19/48/9 ...	1·3
19/23/16 ...	1·7
19/2/16 ...	1·0
19/37/12 ...	1·0
19/48/16 ...	0·86
19/44/9 ...	1·3
19/37/1 ...	1·2
19/5/9 ...	1·5
19/36/12 ...	1·5
19/17/16 ...	1·0
19/30/1 ...	1·0
19/35/18 ...	1·0
19/25/3 ...	1·07
19/17/15 ...	0·7
19/25/15 ...	1·0
19/42/3 ...	0·7
19/26/2 ...	1·3
19/17/11 ...	1·0
19/17/1 ...	0·7
19/30/6 ...	0·9
Significant difference at 5% level ...	0·57

From the above data it is evident that all the clones are susceptible to Jassid attack. Certain clones are, however, less attacked, and there appears to be some relation between the leaf characters of the clones and the susceptibility to Jassid attack.

Termite control trials:

The incidence of termites was estimated this year in the plots treated in 1955 with Aldrin and Dieldrin at Silcoorie and Borokai Tea Estates. The results are given in tables 7 and 8.

Table 7: Silcoorie Trial (1955)

Date of treatment— April, 1955. Date of observation— December, 1957.

Treatments	Average No. of earth-runs per bush (Mean of 5 replicates).
Aldrin 40% W. P. @ 2 lbs. active material per acre ...	0·020
Aldrex 24 E. C. @ 2 lbs. active material per acre ...	0·028
Dieldrin 50% W. P. @ 2 lbs. active material per acre ...	0·020
Dieldrex 18 E. C. @ 2 lbs. active material per acre ...	0·008
Aldrin 5% dust @ 80 lbs per acre (4 lbs. active material) mixed with S. O. A.	0·012
Aldrin 5% dust @ 80 lbs. per acre (4 lbs. active material) mixed with oilcake	0·004
Dieldrin 1% dust @ 400 lbs. per acre (4 lbs. active material) mixed with S. O. A.	0·000
Dieldrin 1% dust @ 400 lbs. per acre (4 lbs. active material) mixed with oilcake	0·004
Check (untreated)	0·190
Significant difference at 5% level	0·040

The results prove that all the treatments are significantly superior to check in maintaining the reduction in the incidence of termites in the third year after application. As before there was no significant difference in the efficiency between the treatments of Aldrin and Dieldrin applied alone as a spray @ 2 lbs.

active material or applied broadcast @ 4 lbs. active material mixed with fertilizers.

Table 8 : Borokai Trial (1955)

Date of treatment—April, 1955. Date of observations—December, 1957.

Treatments	Average No. of earth-runs per bush (mean of 4 replications)
Aldrex 24 E. C. @ 4/5 gallons per acre (2 lbs. active material)	0·90
Aldrin 5% dust @ 80 lbs. per acre (4 lbs. active material) mixed with S. O. A.	0·96
Aldrin 5% dust @ 80 lbs. per acre (4 lbs. active material) mixed with oilcake	1·35
Dieldrin 1% dust @ 400 lbs. per acre (4 lbs. active material) mixed with S. O. A.	0·79
Dieldrin 1% dust @ 400 lbs. per acre (4 lbs. active material) mixed with S. O. A.	0·66
Check (untreated)	1·59
Not significant	

As mentioned in previous reports there was no significant difference in the termite incidence between the treatments and check in the year of treatment, whereas both Aldrin and Dieldrin @ 4 lbs. active material per acre applied broadcast mixed with oilcake and Dieldrin at the same rate applied broadcast with sulphate of ammonia showed significant reduction in termite incidence over check in the year following treatment (1956).

Pink mite (Acaphylla theae (Watt) Keifer) :

Further studies on the life-history of the pink mite was made. It undergoes two moults before becoming an adult. During winter (December) when the duration of the nymphal stage is 6-7 days, the first moulting takes place 3-4 days after it hatches out from the egg, and the second moult prior to becoming an adult.

Relative population of the pink mite on the Assam kinds of tea and China hybrids were estimated at Tocklai and the results show that the Assam kinds of tea are more susceptible to pink mite attack than the China hybrids (Table 9).

Table 9: Population of Pink mite on Assam & China types of leaves.

Type of tea	Total No. of adult & young mites on 50 leaves.	Average per leaf.
Assam	399.4	79.9
China	654	13.1

The details on the life-history and control of the mites have been presented in a paper which has already been sent for publication.

Control.— A field trial was carried out with Akar, Aramite and Malathion, along with Lime sulphur and a wettable sulphur which were both being used for control of the mite. Assessment of the comparative efficacy of the acaricides was made after a week and again after two weeks of the treatment with the following results (Table 10).

Table 10: Pink mite Control

Treatments	Average population per leaf after	
	One week	Two weeks
Lime sulphur containing 22-26% polysulphide at 1 in 40 parts water	3.8	2.1
Thiovit (a wettable sulphur) at 1 lb. in 10 gallons water	1.4	4.1
Akar 338 at 1 in 500 parts water	17.2	5.1
Malathion 50% E. C. at 1 in 500 Parts water	44.1	26.0
Aramite 15% W. P. at 1 lb. in 50 gallons water	98.8	26.8
Check	409.0	129.4
Significant difference at 5% level	146.7	23.3
Rainfall between treatment and observation	19.69 cm.	34.72 cm.

From the results of observation taken after one week, it is evident that all the acaricides proved to be equally effective in bringing the pink mite population to an extremely low level. Further reduction in its population was effected after two weeks.

Evaluation of pesticide residues on made tea :

Fifty one samples of made tea and sundried tea, treated with Aramite, Akar, Endrin, Aldrin and Dieldrin have been prepared and sent to the respective manufacturers of these chemicals for evaluation of their residues in connection with the establishment of residue tolerances for these chemicals on made tea. In connection with prepartion of some Aramite treated samples, the Scientific Department, United Planter's Association of South India also co-operated with us.

Tea Seed Bug (Poecilocoris latus Dall.) :

A trial was carried out against Tea Seed Bug at Bharnobari T.E. in Dooars with Basudin (containing 20% Technical Diazinon) and Malathion (0,O-dimethyl dithiophosphate of diethyl mercapto-succinate).

Table 11: Tea Seed Bug Control.

Treatments.	Per cent living bug.	Per cent living transformed into angles.
Basudin 20% at 1 in 500 parts water applied as spray	93.31	80.74
Basudin 20% at 1 in 500 parts of light Diesel oil applied as fog by a fog generator (Swinfog)	94.69	83.77
Malathion 5% Swinfog solution as a fog	89.51	75.52
Check	100 00	90.00
Insignificant.		

None of the insecticides proved to be effective in controlling the tea seed bug.

Flushworm, other Leafrollers & Leaf Tiers:

Monthly observations on the incidence of flushworm (*Laspeyrisia laucostoma*), leaf rollers (*Gracilaria theivora* and *Striglina glareola*), Tea tortrix (*Homona coffearia*) and Sandwich caterpillar (*Agriophora rhombata*) were made on early (September) and late (March) pruned teas at Borbhetta during the year 1957 with the following results:

Table 12: Incidence on early pruned tea.

Months	Average Number (per bush)				
	Flushworm	Gracilaria	Homona	Striglina	Sandwich
December, 56	0·05	0·08	0·00	0·00	0·00
January, 57	0·20	1·04	0·01	0·01	0·00
February ...	0·22	0·78	0 00	0·00	0 03
March ...	0·14	0·59	0·01	0·00	0·04
April ...	0·15	0·25	0·04	0·02	0·03
May ...	0·09	0·14	0·01	0·01	0·02
June ...	0·09	0·14	0·01	0·01	0·01
July ...	0·14	0·16	0·01	0·03	0·01
August ...	0·08	0·12	0·01	0·03	0 01
September ...	0·11	0·11	0 00	0·06	0·03
October ...	0·08	0·11	0·00	0·03	0·02
November ...	0·08	0·11	0·01	0·01	0·01
Av. for year ...	0·12	0·30	0·01	0·02	0·02

Table 13: Incidence on late pruned tea.

Months	Average Number (per bush)				
	Flushworm	Gracilaria	Homona	Striglina	Sandwich
February, 57	0·11	0·35	0·00	0·00	0·09
March ...	0·16	0·60	0 00	0 00	0·12
April ...	0·09	0·17	0·00	0·00	0·06
May ...	0·12	0·13	0·00	0·01	0·02
June ...	0·07	0 06	0·00	0·00	0·01
July ...	0·08	0 08	0·01	0·02	0·03
August ...	0·04	0·07	0·00	0·03	0·02
September ...	0·03	0·05	0·00	0·01	0·00
October ...	0·03	0 03	0·00	0·01	0·00
November ...	0·06	0·22	0·01	0·03	0·04
December ...	Pruned	...	...	...	...
Av. for 11th months...	0·07	0·15	0·00	0·01	0·04

Observations will have to be continued for some years before any conclusion can be drawn.

Parasites of Flushworm.— Only two species of hymenopterous parasites have so far been bred from the larvae of Flushworm. These are (1) *Asympiesella* sp. (Eulophidae) and (2) *Apantales* sp. (Brachonidae).

Asympiesella sp.—This is a primary parasite of *Gracilaria theivora* but it also occasionally attacks the Flushworm.

Apantales sp.—This is an endoparasite. The caterpillars of late instars are usually parasitised.

Field collection of infested shoots was made at Borbhetta and the parasites were bred from the larvae in the laboratory during the months of January to July.

Table 14: *Degree of Parasitisation by two species of parasites.*

Months	Total No. of Caterpillars	No. of caterpillars parasitized	Per cent parasitized
January	388	41	10·6
February	383	24	6·3
March ...	111	18	16·2
April	125	20	16·0
May	58	8	13·8
June	63	12	19·0
July	38	3	7·9

Parasites of leaf roller.— Two hymenopterous parasites have also been bred from the larvae of *Gracilaria theivora*. These are (1) *Asympiesella* sp. and (2) a species belonging to the genus near *Elachertus*, family Euplophidae.

Table 15: *Degree of parasitization by two species of parasites.*

Months	Total No. of caterpillars	No. of parasitized caterpillars.	Percent parasitization.
January	248	111	44·8
February	248	112	45·2
March	84	49	58·3
April	41	5	12·2
May	43	15	34·9

Incidence of Flushworm in relation to Dieldrin treatment of soil.— Reports have been received from a number of estates of the increase of Flushworm as a result of Dieldrin treatment of soil for control of termites. In order to find out if there is any relation between the incidence of Flushworm and Dieldrin treatment, assessment was made on 500 bushes in 10 groups of 50 bushes each selected at random from the treated sections and similarly from the untreated sections of an estate which applied Dieldrin for control of termites.

Table 16: Incidence of Flushworm.

Percent infested shoots	
Treated	Untreated
31·38	33·28
t = 2·92	
Significant at 5% level	

From the above results it is evident that Dieldrin applied as a soil treatment did not increase the Flushworm; on the contrary, there was significant, though small, reduction in its incidence in Dieldrin treated sections.

Coccids:

Taxonomic studies on the coccids attacking tea are being continued. A species of coccidae on tea at Borbhetta has been found to be new and has been described as *Velataspis serrulata*.

Association of ants with the honey-dew excreting Coccids:

A summary of observations on the association of ants with tea coccids are presented here and the details will be published elsewhere.

1. Certain species of Coccidae that excrete honey-dew and are attended by ants or enclosed in their nests are quite prevalent on tea bushes and seed trees in the plains but those which are not attended by ants are kept under considerable check by the

activities of their natural enemies. In Darjeeling where the natural enemies are fewer, a number of species occur abundantly and are often responsible for serious damage to tea.

2. From the studies of the relative population of the ant, *Crematogaster dohrni* and the coccid, *Saissetia formicarrii*, occurring on tea bushes it is doubtful if more than a small portion of the food requirement of the vast ant population in the nests which contain sexual forms could be met from the honey-dew excreted by the small number of coccids enclosed therein. The major part of food must, therefore, come from other sources.

3. Insects attacking or visiting the tea bushes and tea seed trees or even those found on the ground appear to constitute the major part of the food of the ants, *C. dohrni* and *Oecophylla smaragdina.*

4. Several factors are responsible for the decrease in the population or disappearance of the coccids in the absence of attendant ants. In the plains, *Eriochiton theae*, *Coccus hesperidum* and *S. formicarrii entirely disappear in the absence* of attendant ants either due to the activities of their natural enemies or by contamination with honey-dew accummulation or both.

5. Parasitisation may be slightly increased on ant-free colonies, but no estimation was possible since the coccids were shortly destroyed by the predators or as they died out as a result of honey-dew accumulation.

6. The ants do not protect the coccids from Hymenopterous parasites but the disturbance caused by their movement during oviposition of the latter reduces the rate of parasitisation.

7. In the presence of the ants, *O. smaragdina* and *C. dohrni*, predators are rare.

8. Predators are destroyed or driven away, as are any other insects that happen to be near their habitat whether they constitute food or not. The larvae of predators which have a protective covering or which resemble the coccids, if they happen to be in the Coccid colonies, are not attacked by the

ants, because they are not recognised as different from the Coccids.

9. *O. smaragdina* does not normally transport the Coccids, though young nymphs of *E. theae*, and *C. hesperidum* may be aided in their dispersal but *Crematogaster dohrni* and *Crematogaster* sp. are primarily responsible for the dispersal of the Coccid, *S. formicarrii* and this takes place when an occasion arises to remove the Coccid to more favourable sites.

10. *O. smaragdina* does not destroy the nymphs and sedentary form of the Coccid, *C. hesperidum* for food, but sedentary forms are eaten when carried by the ants from withered leaves into its nest.

11. With the control of the attendant ants, the honey-producing Coccids disappear or at least they become rare, but where the Coccids are controlled, the ants automatically disappear.

Red spider (Oligonychus coffeae):

Clonal susceptibility to Red spider attack.— The intensity of Red spider attack was estimated on different clones at Tocklai in May and the results are presented in the following table.

Table 17: Clonal susceptibility.

Clone No.	Average intensity of attack per bush (Mean of 3 replicates)	Clone No.	Average intensity of attack per bush (Mean of 3 replicates.)
19-48- 9	2·70	19-11-11	1·07
19-48-16	2·47	19-37- 1	1·00
19-29- 7	1·80	19-30- 1	0·93
19-29-12	1·67	19-25-15	0·93
19-37- 1	1·60	19-17-11	0·93
14- 4- 1	1·53	19- 2-16	0·93
19-23-16	1·40	19-35-18	0·87
19-30- 6	1·33	19-13-13	0·80
19-32-12	1·27	19-26- 2	0·80
19- 2-79	1·27	19-42- 3	0·73
19-37-12	1·27	19-22- 4	0·67
19-17-16	1·13	19-44- 9	0·67
19-25- 3	1·13	19-36-12	0·67
19-17-15	1·07	19-17- 1	0·60
Significant difference at 5% level			0·60

Incidence of Red spider and its predators on road-side bushes.— Observations on the incidence of Red spider and its Coccinelid predators occurring on the road-side bushes and those on inner rows, were taken at Sycotta T.E. in April with the following results:

Table 18: Incidence of Red spider and its predators.

Row No. from road	Total No. of bushes.	Average intensity of Red spider attack per bush.	Average No. of predators per bush.
First	12	2·08	0·00
Second	19	3.32	0·00
Third	18	3·22	0·00
Fourth	19	2·89	0·05
Fifth	19	3·26	3·37
Sixth	20	2·15	1·25
Seventh	20	2·00	1·45
Eighth	18	2·44	6·00
Ninth	19	2·11	4·58
Tenth	20	1·65	1·65

Further observations are necessary to arrive at any definite conclusion.

Red spider control.— A field trial was carried out at Borbhetta with Malathion and Lime sulpur as one and two rounds of spray (2nd round after a week).

There were four replicates for each treatment and each replicate consisted of 15 bushes.

Spraying was done by means of a Holder Harridane Knapsack sprayer fitted with low volume nozzle using 80 gallons spray per acre.

Table 19: Red spider control—Field trial.

Treatments	Average Red spider on 10 leaves per bush, 7 days after second spraying	Percent reduction over check.
A. Malathion (1 application) ...	50·50	89·4
B. Malathion (2 applications) ...	2·75	99·4
C. Lime sulphur (1 application)	33·25	93·0
D. Lime sulphur (2 applications) ...	15·00	96·8
E. Check	475·50	...
Significant difference at 5% level ...	110·66	...
Rainfall	7·18"	...

Both Malathion and Lime sulphur were equally effective against Red spider and there was no significant difference between one and two applications of these acaricides.

Nematode parasites of Tea seedlings:

In addition to the common root-knot nematode, *Meloidogyne* sp., another *nematode, Pratylenchus* sp., has been recorded as parasitic in the roots of tea seedlings for the first time in North-East India. The other species that have been found in the galls produced by *Meloidogyne* sp. are either fungal or bacterial feeders or predators.

Fungal feeders —*Aphelenchoides* sp
Tylenchus sp.

Bacterial feeders —*Rhabditis* sp.
Panagrolaimus sp.
Diploscapter sp.
Diplogaster sp.

Predators —*Aphenlenchoides* sp.
Mononchus sp.

Nursery plants of *Desmodium gyroides* are heavily attacked by the root-knot nematode, *Meloidogyne incognita.*

Root-knot nematode control.— A trial has been conducted with the following treatments at Namrup T. E. against *Meloidogyne* sp. attacking tea seedlings in nurseries.

Treatments.

A. Hexamar @ 30 gallons per acre (3 cc per sq. ft.)
B. Shell DD @ 400 lbs. per acre.
C. Nemagon @ 2 gallons per acre.
D. Nemagon @ 4 gallons per acre.
E. Check (Untreated).

The treatments were applied one month before sowing of seeds. The population of nematodes in the soil was estimated immediately before and one month after the treatment with the following results:

Table 20:- Nematode population.

Treatments.	Average population per 10 gms. of soil (Mean of 4 replicates).		
	Before treatment	One month after treatment and before sowing.	Increase (+) or decrease (-) over previous population
A ...	20·0	8·4	(-) 11·8
B ...	23·3	9·5	(-) 13·8
C ...	18·6	9·7	(-) 8·9
D ...	17·0	9·9	(-) 7·1
E ...	14·2	14·8	(+) 0·6
Significant difference at 5% level	...	3·3	...

Incidence of various pests of nursery shade plants :

Observations on the incidence of various pests of nursery shade plants are being continued.

SCIENTIFIC PUBLICATIONS

Das, G. M. Preliminary observations on the leaf-rollers and leaf-tiers of tea with special reference to the Flushworm, *Laspeyrisia leucostoma* Meyr. in North-East India; *Proc. Zool. Soc.*, Calcutta (in Press).

——— Termites affecting tea in N. E. India and their control; *Ind. Jour. Agric. Sci.* (in Press).

Ganguli, R. N. A new species of *Velataspis* on tea ; *Ind. Jour. Ent.* (Communicated).

ADVISORY

Touring.— The Senior Entomologist attended the Scientific Conference of UPASI and Mr. R. N. Ganguli, atetnded the 44th Session of the Indian Science Congress in Calcutta.

The Senior Entomologist also visited Singell, Nagri, Ging, Tumsong and Mim Tea Estates in Darjeeling, Devarshola Research Station and a number of tea estates in South India,

Silcoorie and Serispore Tea Estates in Cachar, Borjuli, Ghoiralli, Sonajuli and Dhulapadung Tea Estates in Darrang District and Koomtai, Dhoolie and Methoni Tea Estates in Upper Assam, and his assistants visited Hashimara Tea Estate in Dooars, Silcoorie Tea Estate in Cachar, Monabarie Tea Estate in North Bank and Koomtai Tea Estate in Upper Assam, in connection with research and experiments.

Correspondence.— 410 letters and memoranda were issued.

Examination of specimens.— Infested tea and ancillary crops 132
Soil samples for eelworm estimation ... 513
Pest control products for test. ... 11

Publications.— (1) Prevention and Control of Borers attacking tea chest panels—Tea Encyclopaedia Serial No. 114 under J. 3.

(2) How to utilize mound-sites for growing tea—'Two and a Bud', Volume IV, No. 2.

(3) *Enarmonia* (*cydia*) *leucostoma* Meyr. (the Flushworm)—Cachar Quarterly, Vol. II, No. 1.

GENERAL REMARKS

Pest incidence.— A heavy incidence of Pink mite was recorded at Tocklai during the second quarter and reports of its incidence were also received from several tea estates in Upper Assam. Red spider attack was fairly high during the early part of the second quarter but the attack subsided with the heavy rainfall in May. Heavy outbreaks of Looper caterpillar were reported from a few estates in the Sibsagar district. Reports of sporadic outbreaks of Flushworm were also received from several gardens in Upper Assam, Cachar and North Bank. Pierid caterpillars were responsible for causing damage to shade trees in localized areas.

PLANT PATHOLOGY BRANCH—MYCOLOGICAL SECTION

K. C. SARMAH—Mycologist

STAFF

The Mycologist was on annual leave for 2 months, from 1st of February to 31st March.

Shri U. Goswami joined the department as Typist on 2nd January and Shri K. C. Barua, M.Sc., as Intermediate grade Assistant on 6th August, vide Shri G. C. S. Barua, B.Sc., promoted to the post of Senior grade assistant. Shri Illah Chutia (Chaprasie) retired on 31st August after about 40 years' service and Shri Bokul Bora has been promoted to his place. Shri K. C. Buragohain, Junior grade assistant retired on 31st December.

RESEARCH AND EXPERIMENT

SCREENING OF FUNGICIDES.

Spraying trials against Black rot:

Black rot at Chinchula T.E. (Dooars).— A spraying experiment against Black rot, during the prophylactic period, was laid out at Chinchula T.E., Dooars, with a view to find out the effectiveness of Kirticopper W. P.—50, a 50% Copper formulation supplied by Messrs. Kirti Chemicals, Bombay. At the same time opportunity was availed also to try out the effect of a sticking agent "Tenac", a Shell product which was stated to increase the effectiveness of fungicides even when they are used at a lower concentration. The experimental area consisted of 6 blocks of 200 bushes each, divided into 4 plots of 50 bushes per plot. The following 4 randomised treatments were applied on 2 occasions at an interval of 17 days between last week of May and 2nd week of June. This period was somewhat later than that recommended in T. E. Serial No. 8/2 under 1.3.

Treatment: (1) Kirticopper WP-50 at 1 lb. in 40 gallons of water.
(2) -do- -do- plus ½ lb. of Tenac.
(3) Coppesan at 1 lb. in 40 gallons of water.
(4) Control.

Assessment on the incidence of the disease was made on 3 occasions, once every month, from July to September and individual bushes were marked by putting

0 for no infection
1 ,, slight infection
2 ,, moderate infection
3 ,, severe infection.

Results are tabulated below:-

Table 1

Date of assessment.	Treatments				Remarks
	1	2	3	4	
I	77	59	71	140	S.D. = 45·85 (P = ·05)
II	194	158	191	268	Not significant.
III	252	227	285	314	-do-

Effects of treatments are significant over the check under the first assessment. Other observations do not show any significant effect. Addition of Shell sticker 'Tenac' to copper fungicide (50% copper) at 1 lb. in 40 gallons of water produced no significant result. The Mycologist is thankful to the Manager for his co-operation and to the S.A.O., West Bengal for conducting the experiment.

Black rot at Dibru-Darrang T.E.— In this estate areas 1 & 2 in Section No. 10 were sprayed prophylactically against Black rot in 1955 and 1956 using 2 copper fungicides viz., Perenox and Coppesan. The fungicides were used at 0.25% concentration without the addition of a spreader in area No. 1 and 'Teepol' was added to the sprays in area No. 2.

In both the occasions spraying gave highly significant results over the control and with these two fungicides addition of Teepol as a spreading agent made no difference. In 1957 the treatments were repeated with some alteration in area No. 2 where instead of using the fungicides at 1 lb. in 40 gallons plus a spreader they were applied at 10 ozs. per 40 gallons of water, to which Shell sticker 'Tenac' was added at the rate of 5 ozs. to 40 gallons of spray fluid.

Spraying was done twice during the prophylactic period at an interval of 18 days. Degree of infection was marked as on previous occasions by putting 0, 1, 2 and 3 points to individual bushes.

Results are tabulated below:—

Table 2: Area 1

Date of assessment.	Treatments			Total
	1 Perenox 0·25%	2 Coppesan 0.25%	3 Control	
I	29	30	174	233
II	101	100	186	387
III	110	111	186	407
Total ...	240	241	546	—

Significant difference required for treatment = 92.55 (P = .05)
Significant difference required between individul figures = 24.09 (P = .05).

Effect of treatments and Date X Treatment interaction are highly significant. There is no difference between the two fungicides. The results compare very well with those obtained in the preceding 2 years.

Table 3: Area No. 2

Date of assessment.	Treatments			Total
	1 Perenox 10 oz. Tenac 5 ,, Water 40 gall.	2 Coppesan 10 oz. Tenac 5 ,, Water 40 gall.	3 Control	
I	47	14	145	206
II	122	73	191	386
III	124	92	201	417
Total	293	179	537	...

Significant difference between treatments = 96.66 (P = .05).

Effect of treatments is significant over the check. Treatment No. 2 is significantly better than treatment 1.

In this trial both the fungicides gave significant results when used at about 2/3 the usual dosage with the addition of Shell sticking agent 'Tenac' at 5 ozs. per 40 gallons of fluid. In section No. 10 at Dibru-Darrang 5 fungicides were used in 1956 against Black rot and as the Manager was very willing to repeat the trials the following treatments were suggested with change of material in treatment Nos. 3 & 4. The area consisted of 6 plots, each plot having $5 \times 10 = 50$ bushes.

Treatments (randomised):

(1) Fytolan 0.25% suspension.
(2) Fungicopper 0.25% ,,
(3) Shell Copper ,, ,,
(4) Shell Copper 10 oz. plus Tenac 5 oz. in 40 gallons of water.
(5) Perenox 0.25% suspension.
(6) Control.

Two applications were made, the first in mid-May and the second in early June after an interval of 18 days. Assessment on the incidence of the disease was made as in the above mentioned tests.

Figures are given below:—

Table 4: Area No. 10

Date of assessment	Treatments						Total
	1	2	3	4	5	6	
I	158	154	185	147	153	343	1140
II	253	191	288	213	265	357	1567
III	181	160	193	163	176	207	1080
Total	592	505	666	523	594	907	...

Significant difference between treatments = 192.7 (P = .05)
Significant difference required between individual figures = 47.12 (P = .05).

All the five spraying treatments are significant over the control but there is no significant difference between these five treatments. In this trial also addition of Shell sticker 'Tenac' to 2/3 of the usually recommended amount of Shell copper fungicide gave effective control. The Mycologist is thankful to the Manager for his keen interest and co-operation in this matter.

Spraying trials against Red rust:

Red rust at Baradighi T. E. (Dooars).— An area consisting of 1200 young tea plants, known to be affected by Red rust, was selected at Baradighi T.E., Dooars. It was divided into 6 blocks, having 4 plots of 50 bushes in each. The following 4 treatments were randomised.

Treatment (1) Coppesan 0.25% suspension.
(2) Kirticopper WP – 50, 0.25% suspension.
(3) -do- plus ½ lb. of Tenac per 40 gallons of fluid.
(4) Control.

Two applications were made during the prophylactic period (April—May). Assessment on the incidence of the disease was made by putting

0 for no orange-red fructifications.
1 ,, slight ,, ,,
2 ,, moderate ,, ,,
3 ,, heavy ,, ,,

The average degree of infection is tabulated below:—

Table 5

Date of assessment.	Treatments				Total
	1	2	3	4	
I	7	4	8	16	35
II	4	2	2	7	15
Total	11	6	10	23	

Significant difference between treatments = 7.16 (P = .05).

Treatments 1, 2 and 3 are highly significant over 4 (control) but there is no real difference between these three treatments. Addition of Tenac to Kirticopper WP-50 had no special advantage in the treatment of Red rust. Thanks are due to the management and also to the West Bengal Advisory Branch for this work.

Red rust at Silcoorie T.E., Cachar.— A spraying trial was carried out against Red rust at Silcoorie T.E., to evaluate the effect of Shell Sticker 'Tenac' when added to the spray fluid. The experimental area consisted of 6 blocks, each of 200 bushes. The following 4 treatments were replicated 6 times (once in each block).

Treatment 1—Shell copper at 1 lb. in 40 gallons of water without sticker.
,, 2—Shell copper at 1 lb. in 40 gallons of water plus ½ lb. of Tenac.
,, 3—Shell copper at 10 ozs. plus 5 ozs. of Tenac in 40 gallons of water.
,, 4—Water (control).

Applications were made twice, during the prophylactic period April—May, at an interval of 2 weeks.

Assessment was made by counting the number of affected stems out of a total number examined from each plot.

Results are not significant, apparently due to the method of assessment being different from the one usually applied. The trial will be repeated in 1958 prophylactic period.

Thanks are due to the Advisory Officer, Cachar, for conducting the trial.

Red rust at Goriahabi.— Another spraying experiment, at Goriahabi T.E. with 3 fungicides, applied twice during the prophylactic period, showed no significant results, probably due to the first spraying being followed by rain and also some irregularity in assessment of the incidence of the disease. The co-operation of the Scientific Officer of Jorehaut Tea Co. Ltd., and the Manager of the estate is thankfully acknowledged.

Chemical control of Brown Root Rot (*Fomes lamaoensis*) and Charcoal Stump Rot (*Ustulina zonata*) :

Field trials with tetrahydro-3, 5-dimethly 1-2H-1, 3, 5-thiadiazine-2-thione (Crag fungicide 974) against the above mentioned root fungi gave the following results.

2 plots of 18 young tea plants in each, were inoculated by placing pieces of tea root, heavily attacked by Brown Root Rot and Charcoal Stump Rot, in direct contact with the tap root. In one case the diseased material was buried for $2\frac{1}{2}$ months, in soil treated with 'Crag 974' @ 400 lbs. per acre, prior to the date of inoculation and in the other case (control) untreated diseased roots were used. In each plot, treated as well as control, 9 plants were inoculated with each disease out of which 1 plant was killed by Brown Root Rot 9 months after inoculation in the control plot and 1 plant again by Brown Root Rot after 17 months in the treated one; another plant in the latter (inoculated with Charcoal Stump Rot) was killed, probably by *Poria hypobrunnea*. All the remaining 33 plants were examined by removing the soil from near the roots but no evidence of infection could be detected. Probably the diseased pieces of

wood were eaten away by white ants (which were very prevalent in the area) before infection took place.

4 plots, $7' \times 4'$ each were subjected to the following treatments:—

(1) Cultivated to a depth of 15″ but otherwise untreated.

(2) 'Crag 974' applied @ 200 lbs. per acre
(3) 'Crag 974' applied @ 400 lbs. per acre
(4) 'Crag 974' applied @ 600 lbs. per acre
} mixed with the soil to a depth of 15″.

Each plot was then divided into two. On one half, tea roots affected by Brown Root Rot were buried in the soil, at 0″ – 5″, 5″ – 10″ and 10″ – 15″ from the surface. Similarly another lot affected by Charcoal Stump Rot was placed in the other half.

After an interval of $2\frac{1}{2}$ months, 6 healthy young tea plants were planted, in each sector, with their roots in direct contact with the diseased material in the soil. They were then kept under observation, for any symptoms of disease, for over 2 years. During this period the following results were obtained.

Table 6

Treatments	Disease	Deaths apparently due to drought	Living plants	Deaths obviously due to disease
1. Control	Charcoal Stump Rot	2	4	—
	Brown Root Rot	3	2	1
2. 'Crag 974' 200 lbs/acre*	Charcoal	4	1	1
	Brown	2	—	4
3. 'Crag 974' 400 lbs/acre	Charcoal	1	4	1
	Brown	1	1	4
4. 'Crag 974' 600 lbs/acre	Charcoal	3	—	3
	Brown	2	2	2

*Amount per acre recommended by the manufacturers = 200 lbs.

Results of laboratory trials, as well as individual bush treatments in the field (published earlier in annual report for 1956 pp. 109-110) showed no fungicidal or fungistatic effect of 'Crag 974'.

The above figures indicate that 'Crag fungicide, 974' even when used at 3 times the recommended amount, failed to prevent infection of tea plants from diseased woody material contained in the soil.

TEA FLOWER DISEASE—*Botrytis* SP. (*Sclerotiniaceae*).

Field trials :

Spraying trials in the field with 'Fernide' (TMTD) have been carried out by Mr. W. G. L. Austin of Fernhurst in co-operation with the Advisory Branch in 6 different commercial tea seed gardens, viz. Thowra, Deohall, Dhelakhat, Sealkottee, Khorijan and Tingamira. Four applications were made between mid-November and third week of December. These trials are more fully described in the Assam Advisory Branch Report.

The above fungicide was also supplied to Tyroon T. E. for another spraying trial in a polyclonal seed garden. Two more small scale spraying trials have also been conducted, at Tocklai, jointly with the Plant Physiological Branch using 2 fungicides viz. 'Fernide' and 'Phygon XL'.

Results of the trials will be assessed in terms of the weight of seed collected during the harvesting period of 1958.

Cultural studies :

Cultural characters of 8 isolates of *Botrytis* from tea flowers varied on different media. The fungus has been tentatively identified and classified under the *cinerea* group.

27 hosts of *Botrytis* are recorded in and around Tocklai indicating the plurivorous nature of the fungus. All isolates fall tentatively under two groups, namely *cinerea* and *gladiolarum*.

Two types of apothecia are common in the field. One is a short stipitate form and the other is a long stipitate form.

They are similar in all other morphological characters. Ascospore cultures failed to produce any imperfect conidial stages.

Sclerotia of *Botrytis* could not be induced to form apothecia under laboratory conditions. It is indicated that the apothecia found under the seed trees are in no way connected with the *Botrytis* found on tea flowers.

Since the direct inoculation of tea flowers by *Botrytis* is not possible owing to the ubiquitous occurrence of the fungus, platings were done to ascertain the period after anthesis when *Botrytis* colonizes the tea flowers. *Botrytis* is not present in the ovaries even though the styles showed the fungus. Similarly, sepals are free from *Botrytis*. Percentage occurrence of *Botrytis* increased 48 hours after anthesis in petals, stamens and styles. Its occurrence is negligible in sepals. Along with *Botrytis* there is a corresponding increase in other fungi also indicating a sort of mycological succession of a declining substratum rather than active parasitization.

Cultural characteristics of *Botrytis* spp.:

Botrytis spp. found on tea flowers collected from Khoomtai and Tocklai Experimental Station campus were isolated by mass culture and multiplied in the laboratory. Monospore isolates were prepared subsequently by the dilution or streak method and cultural studies on different media, namely, Potato dextrose, Czapek-Dox, Czapek-Dox plus yeast extract, oat agar and sterilized tea flowers were confined to eight of these isolates. Growth of the isolates is similar on all media except Czapek-Dox where there is more of byssoid mycelium and the conidial production is rather tardy. Conidia are produced at the laboratory temperature (51-80°F) in 48 hours and sclerotial initials in 72-96 hours. Sclerotia first appear as glossy, white, elevated spots which gradually assume black colour in about a week's time. The sclerotia are formed in a centripetal order and are typically plano-convexoid.

On potato dextrose agar, growth is rapid giving a continuous mat of white aerial mycelium which later becomes buff-coloured. Conidia are usually produced in tufts or in patches over the surface of the media, varying in abundance,

which may be due to various factors like, light, temperature, humidity and the nutrient substratum (especially the C/N ratio). It was not attempted to investigate these diverse factors. Sclerotia also varied in size and abundance.

On oat meal agar growth is very similar to that on potato dextrose agar. Microconidia are produced in great abundance usually in four to six week old cultures on Potato dextrose agar.

The mycelium is much ramified, hyaline, septate 2 to 3 μ in diameter when young ; the older hyphae are larger and more closely septate and definitely constricted at some of the septa, up to 5 μ in diam., becoming pale tan-coloured.

The dimensions of the conidia and the appearance of the fungus varied greatly on different media. In general, the conidial diameter varied from 10 to 20 by 5 to 8 μ. The microconidia which are found in great profusion are often found to germinate in *situ*. These are colourless, globose or spherical measuring up to 3. 5 μ in diameter, a few being a little larger, 4 μ.

On tea flowers, the mycelium is sparse, while the conidiophores are produced abundantly. On richer media e.g., Czapek-Dox plus yeast or malt extract, the conidia are produced intercalarily also, while on poorer media they are found to occur acrogenously.

The pale brown conidiophores arise in fascicles from dark, thick-walled, closely septate hyphae near the surface of the substratum or from the sclerotia. They vary in length from 0.2 to 0.8 mm. and 4-6 μ in diameter, broader at the base and slightly narrower apically. Each conidiophore consists of a main axis toward the apex of which are given off several short branches more or less extensively divaricate. The ultimate hyaline, thin-walled branchlets of the developing conidiophores are somewhat dichotomously forked, the tips swelling to form the "ampullae" upon which numerous spiny sterigmata appear. The tips of the sterigmata rapidly swell to form the young conidia. The sterigmata on which these conidiospores are borne are to be distinguished only before the conidia are fully

grown. When the conidia are mature, traces of the sterigmata are no longer to be discerned, either on the conidia or on the collapsed ampullae.

Other hosts (substrata) on which *Botrytis* spp. were recorded :

Botrytis spp. are recorded on many plants that come to bloom during the period between October and early March and a list of the plants in and around Tocklai on which Botrytis spp. were observed is presented herebelow :—

1. *Poinciana regia* Bojer.
2. *Clerodendron infortunatum* L.
3. An unidentified mimoseae.
4. *Tephrosia candida* DC. (Flowers, leaves and pods).
5. *Stylosanthes guyanensis* Sw. var *gracilis* (H. B. K.) Vog. (leaves and flowers).
6. *Crotalaria brownei*.
7. *Crotalaria anagyroides* H. B. K.
8. *Dianthus* sp.
9. *Tropaeolum majus* L.
10. *Zinnia elegans* Jacq.
11. *Petunia* sp.
12. *Althea rosea* Cav.
13. *Achania malvaviscus* Swartz. (=*Malvaviscus arboreus* Cav).
14. *Duranta* sp.
15. *Hibiscus rosa-sinensis* L.
16. *Hibiscus schizopetalus*.
17. *Eurya* sp.
18. *Dahlia* sp.
19. *Crossandra* sp.
20. *Nyctanthes arbor-tristis* L.
21. *Euphorbia pulcherrima* Willd.
22. *Lathyrus sativus* L.
23. *Quisqualis indica* L.

24. *Allamanda cathartica* L.
25. *Dombeya* sp.
26. *Salvia* sp.
27. *Rosa* sp.

In view of the great variability in the imperfect conidial fructifications presented by the species of this fungus, it was not possible to identify the different species involved with certainty, nor was it attempted to make an exhaustive study of the cultural characteristics of different isolates under laboratory conditions. All the species of *Botrytis* were isolated from the respective hosts (substrata) by mass culture and conidial and sclerotial characters studied. Conidial dimensions were observed to fall in the range already recorded for *Botrytis* on tea. In general, most of the isolates fall tentatively under two categories, namely *cinerea* or *gladiolarum* type and the sclerotial formation is in a centripetal fashion. In the isolates obtained from *Crotalaria brownei, C. anagyroides, Crossandra sp., Stylosanthes gracilis* and *Dahlia* sp. wherever the aerial mycelium of the cultures came in contact with the glass sides of the culture vessel appressoria developed. This is a character consistent with the species of *Sclerotinia* and *Botryotinia*.

Nature of the apothecia collected from the field :

From underneath the tea-seed trees, apothecia were collected during the period between December to February. Two types of these apothecia are found to be common, both at Tocklai as well as Khoomtai. One is a short stipitate form and the other is a long stipitate form. Often these two are seen occurring together.

The apothecium has an expanded hymenium-bearing portion, the receptacle and a short or a long stipe. Receptacle broadly infundibuliform to flat expanded when mature, fragile, 1-2 (3) mm. in diameter; stipe long or short, slender, concolorous with the cup, being pale brownish, tanny, vinaceous brown or cinnamon brown to avellaneous, becoming livid when dry*. No rhizoidal hyphae are seen at the base. In a few instances the

*Colour characters are described with the help of Maerz and Paul's "A Dictionary of Color", McGraw-Hill, N. Y.

apothecia are subcyathiform. Hymenium even or umbilicate, depressed, fleshy, margin even or sometimes irregular, stipe slightly pubescent above and tomentose to villous at the base; tissue of the hypothecium and stipe prosenchymatous, composed of ascending, more or less parallel to interwoven, hyaline or faintly yellowish hyphae, curving towards the outside to form a more compact excipular zone, appearing pseudoparenchymatous. Subhymenium a narrow, compact zone of closely intertwined, slender, yellowish hyphae. The asci are long, clavate, 40 to 100 by 4 to 8 μ depending on the size of the apothecium; ascospores semiseriate, fusiform-elliptic, hyaline, guttulate, 4 to 9 by 2 to 4 μ. Whether the apothecia are short-stalked or long-stalked their morphological characters are found to be similar.

Well over 150 apothecia collected from the field were critically examined and many of them were observed to arise from an incipient discoid sclerotium mostly found on the remnants of leaf and very rarely on decomposing pericarp. In some instances no sclerotium could be discerned. Neither could we find sclerotia nor apothecia on decaying floral parts.

The apothecia were allowed to mature under laboratory conditions in sterile Petri dishes and the ejected ascospores were used for monascosporous isolations. The ascospores germinate readily in distilled water and on plain agar (1.5%) producing germ tubes from either apex. The growth of the ascospores is very slow in culture forming a pale brown mycelium in a thin mat which assumes a stromatoid texture with the ageing of the culture.

Cultures from nearly 40 apothecia were examined and in no instance was a conidial stage observed in the ascospore isolates. Growing the fungus on sterilized tea flowers was not successful in inducing conidial stage, while growth was totally absent or very restricted on flowers which were washed in changes of sterile tap water and inoculated with ascosporic isolates.

From the work hitherto done, it is obvious that the apothecia occurring on soil under the seed baries either belong to a sclerotiniaceous genus without an imperfect conidial state

or to some hyaline amerosporous genus of the stromatic inoperculate discomycetes (*Helotiaceae*?).

Production of apothecia under laboratory conditions :

Attempts were made to induce apothecial production in culture from the sclerotia produced by isolates of *Botrytis* obtained from tea flowers. Adopting the technique of Bedi, three-month-old sclerotia from potato dextrose agar were floated on sterilized distilled water in Petri dishes and Erlenmeyer flasks. No apothecial production was observed even after 4 to 5 months of incubation at the laboratory temperature.

Similarly, sclerotia placed on sterile, moist sand failed to form any apothecia. Methods used by Drayton and Drayton and Groves were also employed. To obtain sclerotia in abundance, the most favourable substratum was used. This was prepared by adding 16 g. of wheat grains to 50 ml. of distilled water in Erlenmeyer flask and sterilizing in an autoclave for 30 minutes at 15 lb. steam pressure. Cultures were grown on this medium (cooked wheat grains) in the dark in an Electrolux refrigerator, the temperature of which was adjusted to 14°C. The sclerotial production was complete in about 5 weeks. Then followed a period of 2 weeks in dark at 5°C after which the sclerotia were carfully detached from the wheat grains and placed on sterilized sand. A suspension of spermatia from old potato dextrose agar cultures was prepared and added on to the sclerotia in the hope of spermatizing the apothecial initials, if there were any. The suspension was used to moisten the sand also. The wet sand was then carefully spread over the surface of the sclerotia. Following spermatization, dishes were placed in the freeze chamber of the refrigerator, adjusted to 0°C for a period of two weeks before being placed under bell-jar. Spermatization was again effected for the second time before placing them under bell-jar. The plates were protected from direct sun light but exposed to diffuse light from the north.

The entire schedule from the time the fungus was first planted on sterilized wheat grains to the final stage took about

5½ months. Unfortunately no apothecial production has been observed till now. Further attempts will be made for inducing apothecia under cultural conditions before any definite conclusions are drawn from the work hitherto done.

However, it may be indicated here that the inability of the sclerotia to produce apothecial initials may be due to inadequate cultural conditions afforded for their development since we could not find any during the course of our investigations or it may equally be not improbable that we are dealing with a *Botrytis* which has no apothecial stage at all and we have a good many reference of such a nature in the literature.

It is quite evident from our work that the apothecia found on the ground underneath the tea seed baries are in no way connected with the *Botrytis* spp. found on the tea flowers.

Other Research Work

Studies on Soil and Rhizosphere Microflora :

No information regarding the distribution, density, quality and activity of the soil microflora which constitutes one of the most potent biologic factors in determining the parasitism, saprophytism and survival of the various root disease fungi is available with respect to the tea soils.

A preliminary study of the rhizosphere microflora of tea growing in Tocklai Experimental Station campus has been attempted using Agnihothrudu's (1953) method. A few local soils also have been screened for the qualitative nature of the microflora by Warcup's (1952) technique. Different methods of study are being investigated for their suitability.

Work hitherto done indicates greater accumulation of fungi, bacteria and actinomycetes in the rhizosphere than in the control soils. A decreasing *rhizosphere effect*, namely bacteria >fungi > actinomycetes was observed.

Following the standardization of the techniques, intensive investigations on the qualitative and quantitative nature of the rhizosphere and soil microflora in relation to the biology of the root disease fungi is contemplated.

SCIENTIFIC PUBLICATIONS.

(1) V. Agnihothrudu—"A new Record Of A Rare Fungus From Tea Rhizosphere"—*Science* and *Culture*, Vol. *22*.

(2) K. C. Sarmah and V. Agnihothrudu—"*Septobasidium theae* from Assam"—*Science* and *Culture*, Vol. 23, No. 10.

(3) V. Agnihothrudu—"*Kutilakesopsis*, A New Genus Of *Tuberculariaceae* From North East India"—*Journal* of the *Indian Botanical Society* Vol. XXXVI, No 3.

(4). V. Agnihothrudu—"A New Species Of *Discosiella* from Assam"—*Journal of the Indian Bot. Society* (accepted for publication).

ADVISORY

Touring.— 11 gardens were visited by the Mycologist in connection with disease control and spraying trials. The Senior Assistant Mycologist visited a Darjeeling estate to investigate 'Thorny Stem Blight' (*Aglaospora* sp.)

Lectures and Demonstrations.— An address was given on 'Diseases in Relation to Environment', at the fourteenth annual conference, on the 12th of November. The following persons received training in diseases of tea and its ancillary crops.

(1) Messrs. D. J. Gray & W. J. Grice for 2 weeks.

(2) Mr. L. Moorlee, Agricultural Officer from Mauritius for 1 week.

(3) 8 apprentices, in 2 groups, for a period of 2 weeks each.

(4) 6 newly appointed assistants, (for pest & disease survey) in 2 groups, for 3 months each.

Examination of specimens and samples.— The following were received for examination.

(1)	Diseased specimens of tea, shade plants and green crops	455
(2)	Water samples for bacteriological test ...	34
(3)	Plant protection products for trial ...	1
	Total ...	490

Correspondence.— 296 letters and memoranda were issued in connection with the above samples and disease control.

Publications.— (1) Chemotherapy of Fungal diseases of plants—"Two and A Bud", Vol. IV, No. 2.

(2) T. E. Serial No. 119, under E. 1, on the Control of Diseases of Green crops.

(3) Serial Nos. 36/1 and 61/1 under I.4, 65/1 under I.3 and 68 under I.4 were revised.

(4) 'Diseases in Relation to Environment'—"Two and a Bud" Vol. IV, No. 4.

(5) Work was completed on the manuscript of a hand-book on "Diseases of Tea and Associated Crops in North East India".

GENERAL REMARKS

Blister blight :

Reports on the incidence of Blister blight were received from the following number of estates, either through the estate managers or through the Advisory Officers.

Table: 16

	Assam.	Cachar.	W. Bengal.	Remarks.
January	1	1	2	
February	...	23	...	
March	...	1	1	
April	2	...	...	
May	...	...	1	
June	1 (1st week)	...	...	
December	...	1	...	

The disease occurred in a wide spread manner in Cachar during the cold weather and it was declared to be in epidemic form, by the local Advisory Officer, in a special circular, in the following areas.

1. Whole of Hailakandi circle.
2. Most of Longai Valley circle.
3. Parts of N. West Cachar and Lakhipur circles.
4. Scattered gardens in Chatla Bheel and Happy Valley circles.

The reasons for the outbreak were attributed to (1) early cessation of plucking to comply with crop restrictions, (2) abnormally heavy rains during November/56—January/57 and (3) unusually prolonged cool weather.

Widespread and severe attack during the cold weather was also reported in a number of areas in the Dooars, by the Senior Advisory Officer there, due to cold, wet weather.

No incidence of the disease was reported from the 1st week of June to end of November.

Aglaospora **sp.:**

Field investigations on the incidence of the disease in Darjeeling tend to confirm the views already advanced in the past. These are—

(1) the fungus is a typical wound parasite.

(2) where the conditions are such that they reduce the general vitality of the bush the fungus establishes firmly on the branches.

(3) the disease is most common on old tea which has well past its economic life; on such tea greater incidence may be due to greater number of unhealed wounds inflicted by way of pruning cuts in the past and above all due to the declining vigour of the plant itself.

(4) the fungus gradually spreads down through the main stem into the roots when the bush is completely killed.

Drought :

Almost all the tea districts of Assam experienced a droughtly period accompanied by strong sun in the spring. In certain places it caused death of young plants which had already made some new growth after decentering and in others scorching of the leaves on mature tea was effected. The latter was followed by an attack of Brown and Grey blights.

Important diseases :

Routine record on the incidence of important diseases of tea and shade trees, built up from examination of diseased specimens received at Tocklai and from the observations made by the Advisory Officers shows the places of occurrence in the following table.

Table: 17

Diseases.	Assam Valley.	Cachar.	Dooars.	Darjeeling.	East Pakistan.
1. Charcoal Stump Rot ...	13	5	7	...	...
2. Brown Root Rot ...	4	...	7	...	...
3. Black Root Rot ...	1	...	...	...	...
4. Purple Root Rot ...	...	...	2	...	...
5. Violet Root Rot ...	6	1	...	...	...
6. *Poria hypobrunnea* ...	21	2	6	...	1
7. Thorny blight ...	...	...	1	2	...
8. Black rot ...	13	4	1	...	...
9. Blister blight ...	4	26	4	...	...
10. Red rust (*Cephaleuros parasiticus*) ...	36	3	10	...	...

Incidence of diseases on hosts other than tea :

The following fungi have been recorded during the year.

1. Black rot (*Corticium theae*?) on *Calopogonium mucunoides*.
2. *Botrytis* spp. (see pages 143-144).
3. Brown rust (*Uromyces achorus* Sydow) on *Dalbergia* sp. and a hyperparasite of the rust *Darluca filum* (Biv.—Bern. ex Fr.) Cast.
4. *Camptomeris* sp. on leaves of *Albizzia falcata* (L.) Backer and A. *lebbek* (L.) Benth.
5. *Cercospora subsessilis* (H & P) Sydow on young *Melia azadirach*, used as shade in tea at Tocklai.

6. *Cytospora* sp. on *Albizzia richardiana.*

7. *Daldania concentrica* (Bolt. ex. Fr) Ces & de Not. on *Derris robusta.*

8. *Ganoderma lucidum* (*Fomes lucidus*) on *Albizzia odoratissima.*

9. Jew's ear fungus (*Auricularia auricula*) on *Gliricidia sepium* (Jacq.) Stendl.

10. *Macrophoma* sp. (*M. theicola*?) on *Albizzia falcata* and *Milletia dura* (young plants).

11. *Phomopsis* sp. on *Albizzia richardiana.*

12. *Pythium* sp. on *Priotropis cytisoides.*

13. Red rust (*Cephaleuros parasiticus*) on *Accacia lenticularis, Adanenthera pavonina, Albizzia sumatrana, Crotalaria brownei, Indigofera dosua, I. teysmani* and *Melia azadirach.*

14. *Rhizoctonia destruens* on *Crotalaria brownei.*

15. Rust (*Uromyces decoratus* Sydow) on *Crotalaria anagyroides.*

BACTERIOLOGY

Bacteriological tests of the Tocklai water supply were made twice a week during the year.

Results as monthly averages are tabulated below:

Table: 18

Months.	Untreated Tank water.		Treated water.		Remarks.
	Total bacteria per c.c.	Lactose fermenters per c.c.	Total bacteria per c.c.	Lactose fermenters per c.c.	
January ...	45	3	0	0	
February ...	55	3	·3	0	
March ...	67	6	1	0	
April ...	169	151	0	0	
May ...	77	45	·4	0	
June ...	52	26	3	1	
July ...	32	7	2	·2	
August ...	159	80	0	0	
September ...	126	117	1	0	
October ...	125	21	1	0	
November ...	216	5	1	0	
December ...	31	7	1	0	

In addition to the above 34 samples of water received from outside estates were tested for bacterial contamination.

APPENDIX

Symptomatology and Etiology of the Tea Flower Disease

By V. Agnihothrudu.

Unfortunately we have little knowledge of the symptomatology of the "sclerotinia disease". In the field, during the flowering season, tea flowers that are withered bear tufts of *Botrytis* conidiophores. In no instance, however, did freshly blossomed flowers show any browning of the floral parts which is ascribed to the earliest clinical symptom in the 'disease'. Nevertheless, there are instances where unopened buds become completely dried, but for the present no attempt has been made to ascertain if any fungus (pathogen) agent is responsible for that syndrome.

In view of the wide host spectrum (plurivory?) of *Botrytis* spp. it was found very difficult to establish conclusively the pathogenecity of the different isolates. There is no effective way in which the flowers found on the plants could be decontaminated and inoculated with spores *in situ*. Although incised flowers become infected (colonized) it is not desirable to aver that the inoculation was successful inasmuch as even the uninoculated controls (checks) showed the fungus after 3 to 4 days of incubation at the laboratory temperature. Besides, detatched flowers being so different from the flowers in *situ*, it is equally impossible to hold beyond criticism the view that the fungus is capable of infection and pathogenesis *in sensu stricto*. It should, however, be recognized in this connection that the ability of the fungus to sporulate on excised flowers may after all be by virtue of the fungus being a primary colonizer of freshly exposed substrata or at best being a vigorous necrotrophic debility parasite (perthophyte).

In view of the aforesaid technical drawbacks in the way of direct inoculation of tea flowers for assessing the role of *Botrytis* in the flower fall which is a *conditio sine qua non* in the establishment of the etiology according to the Koch postulates, we have chosen to partly obviate the difficulties by seeking circumstantial evidence as to the part played by *Botrytis*. From this angle a set of experiments was done and some of the salient features are presented here below.

Distribution of Botrytis and other fungi in the Pistil and Calyx :

The experiment was aimed at isolating all fungi occurring in the pistil and calyx. From the field pistils were selected which showed *Botrytis* on their styles. In most of the cases the pistils chosen were free from petals, the corolla having been shed and they were attached to the plant. No attempt was made to separate the calyx from the pedicel and the term "calyx" is used in the text for sepals together with the pedicel and perhaps also the remnants of the disc.

600 pistils, thus collected were chosen for plating on Potato dextrose agar after surface sterilization. Three surface disinfectants were used, namely 1/1000 Mercuric chloride ($HgCl_2$), 1/14 Bleaching powder (CaO Cl.Cl.) and 1/2 Hydrogen peroxide (H_2O_2). The period for which the different surface sterilizing agents were allowed to act upon different floral parts is given in Table 7.

Table 7: Period (in seconds) for which the disinfectants were allowed to act upon different floral parts.

Disinfectant.	Ovary.	Style.	Calyx.
Bleaching Powder	120	60	180
Mercuric Chloride	45	30	60
Hydrogen Peroxide	180	90	240

The ovary was separated from the style with a sharp blade and the ovary unseated from the cup of the calyx. Before being subjected to the action of the suface sterilizing agent they were dipped momentarily in 25% ethanol in order to facilitate uniform wetting in the process of surface disinfection. This was followed by a thorough wash in sterile tap water. After treating with the disinfectant the floral parts were washed in 8 to 10 changes of sterile tap water and plated on acidified potato dextrose agar (4.0 to 5.0 pH) in Petri dishes. 200 units were plated for each of the three disinfectants. The Petri plates were incubated at the laboratory temperature for a period of 7-10 days before the final identification of the different fungi was made. This involved a meticulous examination of 1800 floral units and the occurrence of different fungi (individual genera) has been expressed as percentage calculated on the basis of 200 floral units per treatment, since in most instances it was not unusual to see more than one fungus genus emerging out of every unit plated. The experiment was done twice at an interval of 12 days and the results are presented in Table 8.

Table 8: Percentage occurrence of different fungal genera in style, Ovary and Calyx.

Floral parts.	Disinfectants.	*Cladosporium.*	*Hormodendrum.*	*Botrytis.*	*Fusarium.*	Sterile Mycelium.	Other Fungi.
STYLE	$HgCl_2$	92 (86)	83 (78)	94 (96)	78 (71)	70 (64)	100 (100)
	CaOCl.Cl	95 (90)	90 (93)	92 (94)	82 (76)	71 (76)	100 (100)
	H_2O_2	91 (94)	80 (90)	96 (94)	80 (85)	65 (62)	100 (100)
OVARY	$HgCl_2$	nil (2)	nil (nil)	3 (5)	2 (3)	nil (nil)	4 (8)
	CaOCl.Cl	nil (6)	1 (4)	2 (nil)	5 (2)	nil (2)	7 (4)
	H_2O_2	nil (nil)	nil (2)	nil (3)	3 (2)	nil (nil)	4 (3)
CALYX	$HgCl_2$	nil (2)	nil (4)	nil (nil)	3 (2)	75 (72)	2 (2)
	CaOCl.Cl	nil (2)	3 (1)	1 (nil)	nil (nil)	63 (58)	4 (2)
	H_2O_2	nil (2)	nil (nil)	2 (2)	4 (nil)	70 (64)	4 (6)

Results of the repeated experiment are given in parenthesis.

As the periods for which the different parts of the flower were exposed to the disinfectant treatment were chosen after preliminary screening, not much of difference between the percentage ocurrence of different fungi in the three suface sterilizing treatments was observed. From the results it is clear that more than 90% of the styles yielded *Botrytis* and *Cladosporium*. Similarly, a high percentage of them yielded *Hormodendrum* and *Fusarium*. Pecentage occurrence of *Botryits* in the ovaries and calyx is negligible.

More than 60% of the calyx plated gave out an unidentified sterile mycelial form. Species of *Botrytis* were not identified. The species of *Cladosporium* namely, *C. herbarum* Link ex Fr., *C. effusum* and *Hormodendrum resinae* Lindau were common. Amongst the Fusaria, *Fusarium semitectum* Berk. et Rav., was the commonest followed by *F. solani* (Mart.) Appel et Wr. var *minus* Wollenweber and *F. scirpi* Lamb. et Faut. Other fungi recorded are, *Aspergillus niger* v. Tieghem, *A. luchuensis* Inui, *A flavus* Link, *A. terreus* Thom, *A. candidus* Link, *Pullularia pullulans* (de Bary) Berkhout, Penicillia of the biverticillata assymmetrica and the divaricata groups, *Gloeosporium* sp., *Cephalosporium* spp., *Cylindrocladium* spp. and *Pestalotia* spp.

The experiment was repeated with almost similar results.

Stage at which Botrytis appears on tea flower :

Having ascertained the distribution of *Botrytis* and other fungi in the pistil and calyx, the next step taken was to investigate the approximate time after anthesis of the flower, *Botrytis* colonizes the different floral parts. With this end in view, a series of platings of petals, styles, stamens and calyx of flowers after different periods of anthesis, ranging from 12 to 72 hours and beyond were done. Unopened flowers 12--18 hours prior to anthesis were also included.

In all instances the floral parts were given a momentary dip in 25% ethanol followed by disinfection in two sterilizing agents, namely mercuric chloride and bleaching powder, the strongest and the mildest of disinfectants. The period for which the surface sterilizing agent was allowed to act upon is given in

Table 9. For style and calyx, the period was same as that recorded in Table 7.

Table: 9 Period (in seconds) for which petals and stamens were exposed to the disinfectant action.

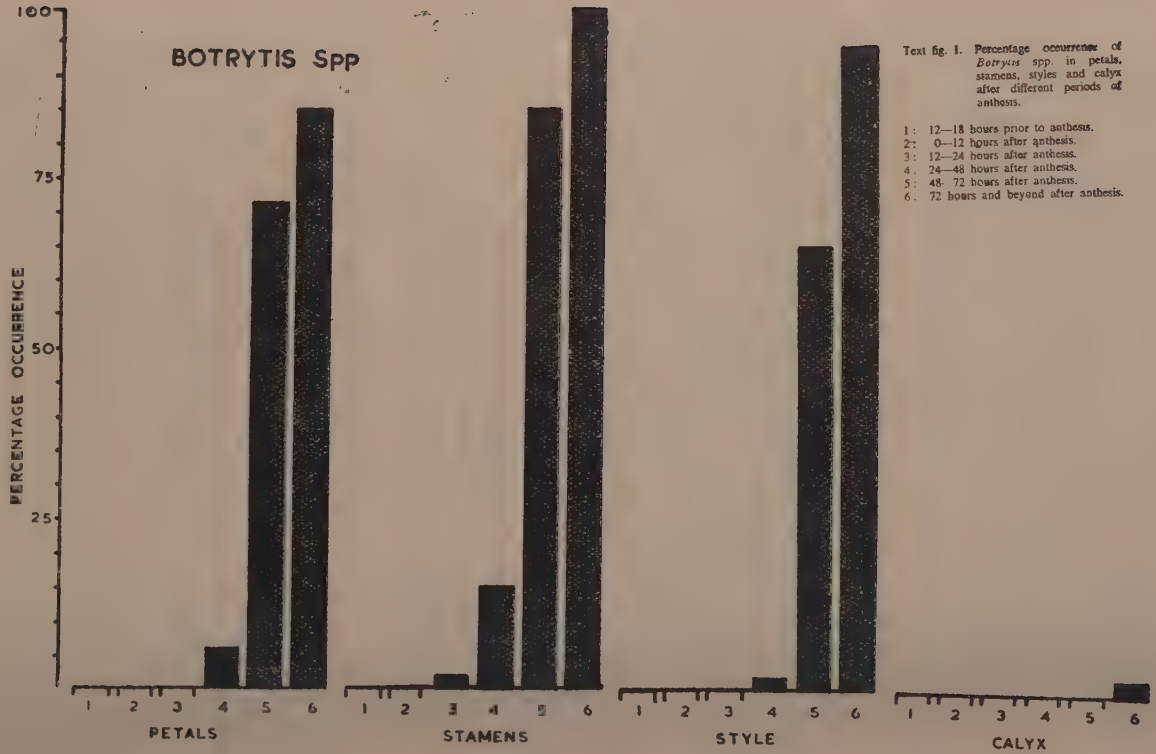
Disinfectant.	Petals.	Stamens.
Mercuric Chloride ...	30	15
Bleaching Powder ...	90	45

100 units each of calyx, petals, stamens and styles were plated for every treatment of the two disinfectants used and the percentage occurrence of different genera recorded in Tables 10 to 15 and Text Figs 1 to 6. At every plating 800 floral units were transferred to acidified potato dextrose agar at the rate of 5 units per plate and observations recorded at the end of 7 to 10 days of incubation at the laboratory temperature. The following are the details of platings:

(1) Flowers 12—18 hours prior to anthesis.
(2) Flowers 0—12 hours after anthesis.
(3) Flowers 12—24 hours after anthesis.
(4) Flowers 24—48 hours after anthesis.
(5) Flowers 48—72 hours after anthesis.
(6) Flowers 72 hours and beyond after anthesis.

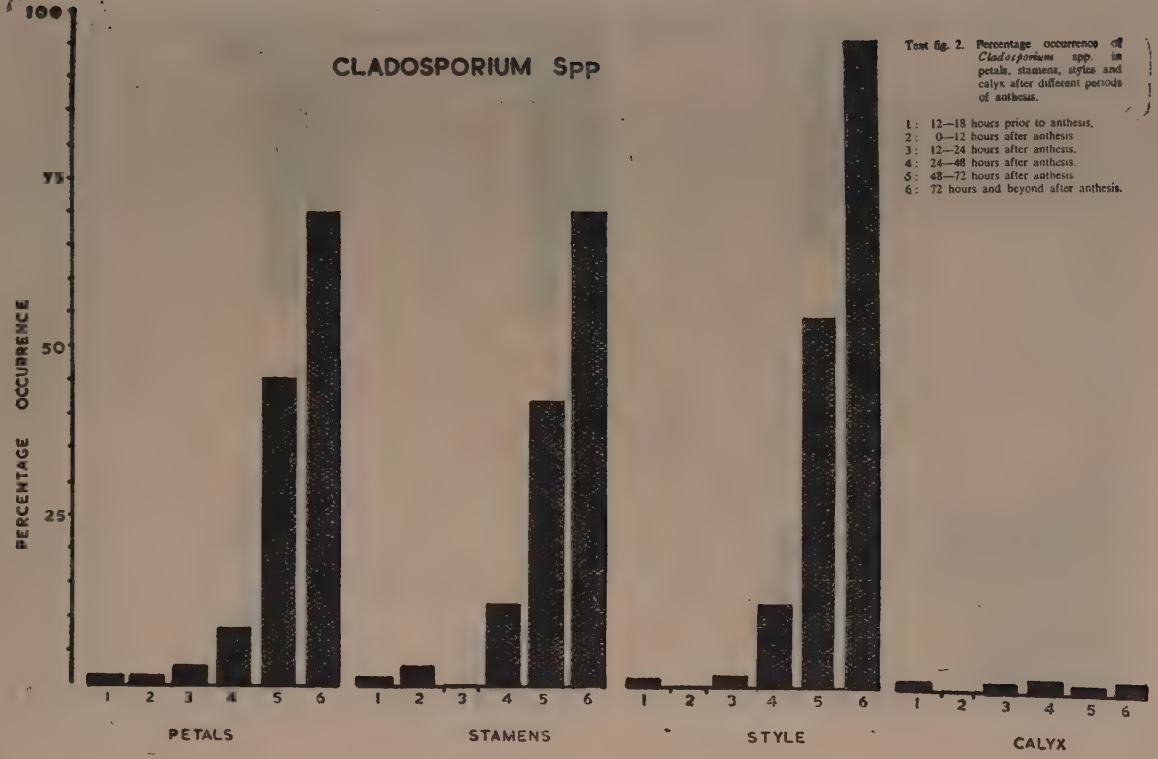
It may be indicated here that the periods before and after anthesis mentioned above are only approximate since they were visually estimated depending on the degree of withering of floral parts, especially corolla and stamens. While the periods before anthesis and up to 48 hours after anthesis may be reasonably accurate it may not be so, however, for periods beyond 48 hours.

In flowers which have not blossomed, neither the petals, stamens nor the styles showed any presence of *Botrytis* (Table 10, Text Fig. 1). Although stray instances of *Cladosporium* were recorded, it is doubtful whether they were from the tissues at all (Text Fig. 2). May be they have come as contaminants in the plates. But, it should be noted that a sterile dematiaceous mycelium was present in the calyx, more than 15% of the calyces plated yielding the fungus (Text Fig. 5).



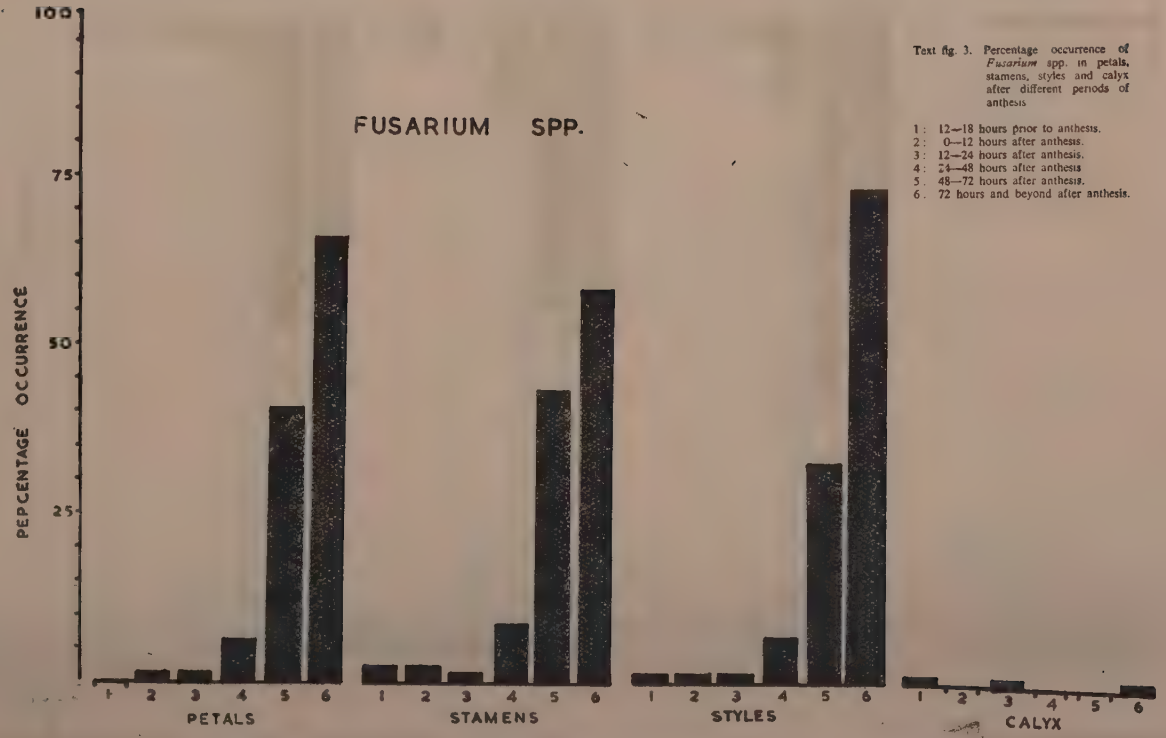
Text fig. 1. Percentage occurrence of *Botrytis* spp. in petals, stamens, styles and calyx after different periods of anthesis.

1 : 12—18 hours prior to anthesis.
2 : 0—12 hours after anthesis.
3 : 12—24 hours after anthesis.
4 : 24—48 hours after anthesis.
5 : 48- 72 hours after anthesis.
6 : 72 hours and beyond after anthesis.



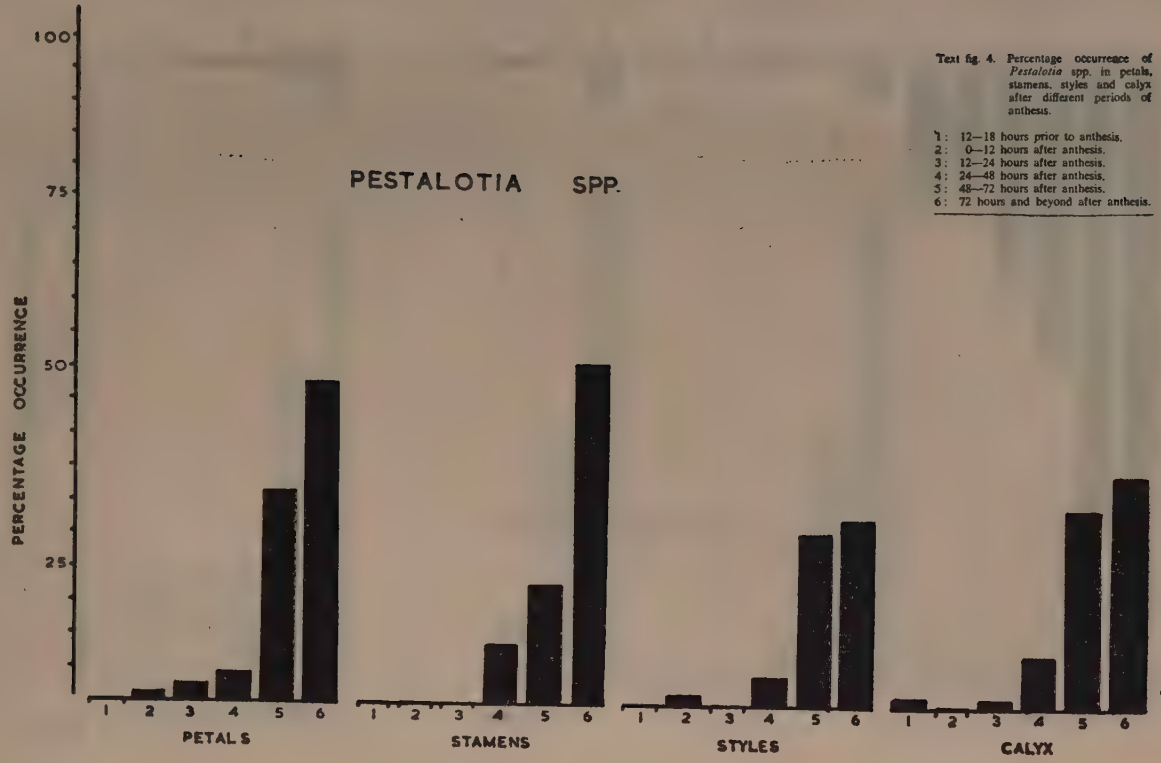
Text fig. 2. Percentage occurrence of *Cladosporium* spp. in petals, stamens, styles and calyx after different periods of anthesis.

1 : 12—18 hours prior to anthesis.
2 : 0—12 hours after anthesis
3 : 12—24 hours after anthesis.
4 : 24—48 hours after anthesis.
5 : 48—72 hours after anthesis
6 : 72 hours and beyond after anthesis.



Text fig. 3. Percentage occurrence of *Fusarium* spp. in petals, stamens, styles and calyx after different periods of anthesis

1 : 12—18 hours prior to anthesis.
2 : 0—12 hours after anthesis.
3 : 12—24 hours after anthesis.
4 : 24—48 hours after anthesis
5 . 48—72 hours after anthesis.
6 . 72 hours and beyond after anthesis.

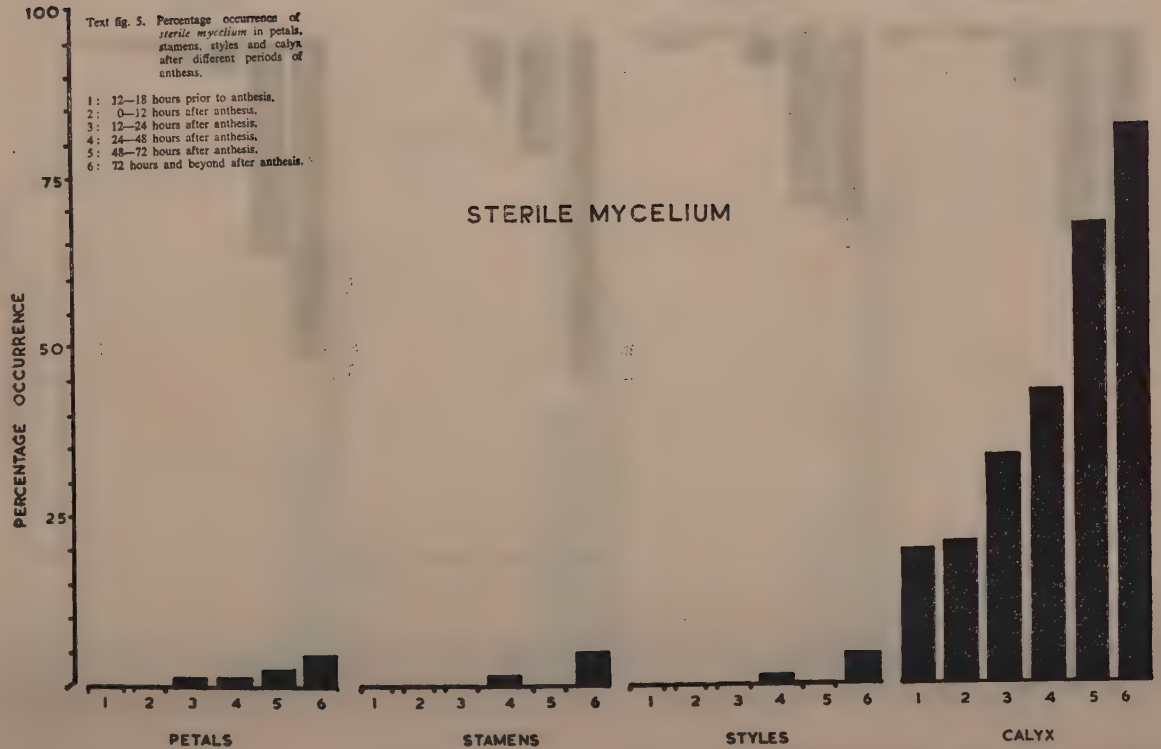


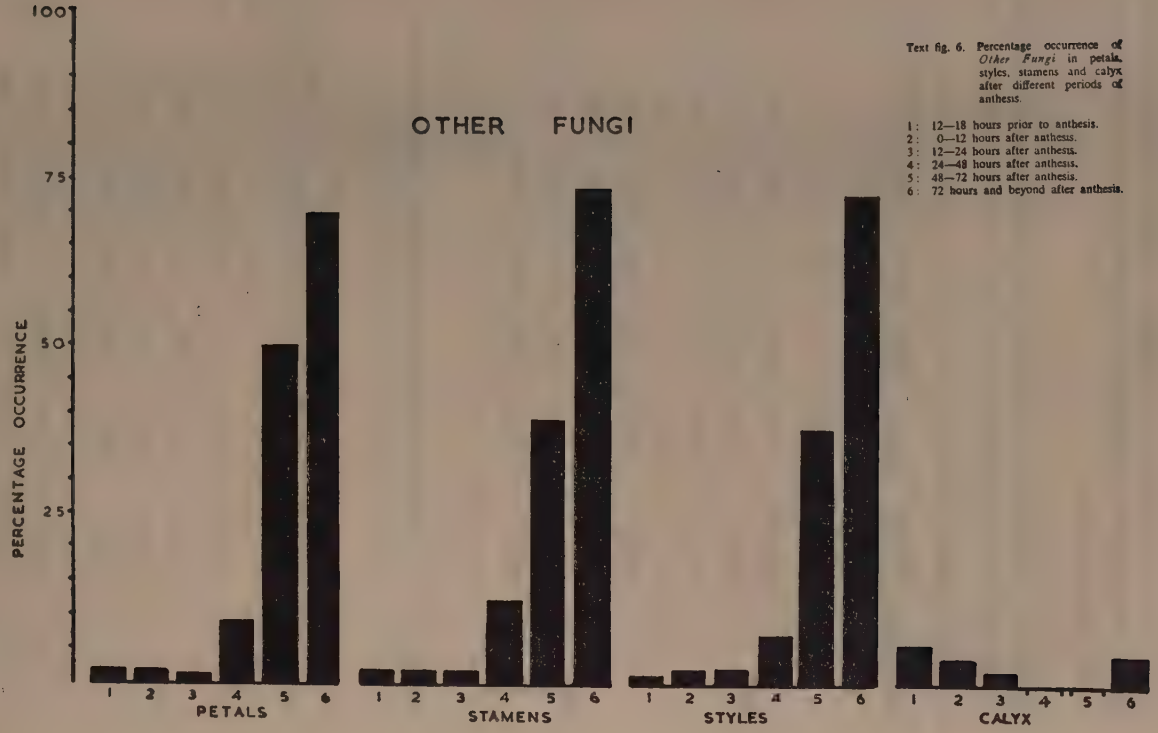
Text fig. 4. Percentage occurrence of *Pestalotia* spp. in petals, stamens, styles and calyx after different periods of anthesis.

1 : 12—18 hours prior to anthesis.
2 : 0—12 hours after anthesis.
3 : 12—24 hours after anthesis.
4 : 24—48 hours after anthesis.
5 : 48—72 hours after anthesis.
6 : 72 hours and beyond after anthesis.

Text fig. 5. Percentage occurrence of *sterile mycelium* in petals, stamens, styles and calyx after different periods of anthesis.

1 : 12—18 hours prior to anthesis.
2 : 0—12 hours after anthesis.
3 : 12—24 hours after anthesis.
4 : 24—48 hours after anthesis.
5 : 48—72 hours after anthesis.
6 : 72 hours and beyond after anthesis.





Text fig. 6. Percentage occurrence of *Other Fungi* in petals, styles, stamens and calyx after different periods of anthesis.

1: 12—18 hours prior to anthesis.
2: 0—12 hours after anthesis.
3: 12—24 hours after anthesis.
4: 24—48 hours after anthesis.
5: 48—72 hours after anthesis.
6: 72 hours and beyond after anthesis.

Since it was not intended to separate the calyx from its pedicel we are not sure at present whether the fungus is from the calyx or the flower stalk.

Table 10: Percentage occurrence of different fungal genera from parts of flowers 12—18 hours prior to anthesis.

Disinfectant	Parts of the flower.	Botrytis.	Cladosporium	Fusarium	Pestalotia.	Sterile Mycelium.	Other Fungi.
$HgCl_2$	Petals	Nil	2	Nil	Nil	Nil	2
	Stamens	Nil	Nil	3	Nil	Nil	2
	Styles	Nil	Nil	Nil	Nil	Nil	Nil
	Calyx	Nil	1	1	1	18	6
CaOCl. Cl	Petals	Nil	Nil	Nil	Nil	Nil	1
	Stamens	Nil	2	1	Nil	Nil	2
	Styles	Nil	1	1	Nil	Nil	1
	Calyx	Nil	Nil	Nil	Nil	22	4

Table 11: Percentage occurrence of different fungal genera in parts of flowers, 0—12 hours after anthesis.

Disinfectant.	Parts of the flower.	Botrytis.	Cladosporium.	Fusarium.	Pestalotia.	Sterile Mycelium.	Other Fungi.
$HgCl_2$	Petals	Nil	2	Nil	Nil	Nil	Nil
	Stamens	Nil	Nil	3	Nil	Nil	2
	Styles	Nil	Nil	Nil	Nil	Nil	2
	Calyx	Nil	Nil	Nil	Nil	16	2
CaOCl.Cl	Petals	Nil	Nil	2	2	Nil	4
	Stamens	Nil	3	Nil	Nil	Nil	2
	Styles	Nil	Nil	1	1	Nil	2
	Calyx	Nil	Nil	Nil	Nil	26	3

Table 12: Percentage occurrence of different fungal genera in parts of flowers 12—24 hours after anthesis.

Disinfectant.	Parts of the flower.	Botrytis.	Cladosporium	Fusarium.	Pestalotia.	Sterile Mycelium.	Other Fungi.
$HgCl_2$	Petals	Nil	2	Nil	2	Nil	2
	Stamens	2	Nil	Nil	Nil	1	Nil
	Styles	Nil	3	1	Nil	Nil	1
	Calyx	Nil	Nil	Nil	Nil	30	Nil
CaOCl.Cl	Petals	Nil	1	1	1	2	Nil
	Stamens	Nil	Nil	1	Nil	Nil	3
	Styles	Nil	2	Nil	Nil	Nil	2
	Calyx	Nil	2	1	1	37	3

Table 13: Percentage occurrence of different fungal genera in parts of flowers 24—48 hours after anthesis.

Disinfectant	Parts of the flower.	Botrytis.	Cladosporium	Fusarium.	Pestalotia.	Sterile Mycelium.	Other Fungi.
$HgCl_2$	Petals	6	8	5	3	Nil	9
	Stamens	18	10	6	8	2	12
	Styles	3	12	6	2	Nil	4
	Calyx	Nil	14	Nil	10	44	Nil
CaOCl. Cl	Petals	8	8	8	4	1	8
	Stamens	14	12	10	10	Nil	10
	Styles	2	10	8	5	Nil	8
	Calyx	Nil	2	Nil	7	39	Nil

Table 14 : Percentage occurrence of different fungal genera in parts of flowers 48—72 hours after anthesis.

Disinfectant.	Parts of the flower	Botrytis.	Cladosporium.	Fusarium.	Pestalotia.	Sterile Mycelium.	Other Fungi.
$HgCl_2$	Petals	68	42	38	28	4	52
	Stamens	82	38	46	18	Nil	38
	Styles	63	52	30	22	3	30
	Calyx	Nil	3	Nil	30	62	Nil
CaOCl. Cl.	Petals	73	48	42	33	2	48
	Stamens	88	46	40	16	Nil	36
	Styles	67	56	36	27	6	39
	Calyx	Nil	Nil	Nil	28	72	Nil

Table 15: Percentage occurrence of different fungal genera in parts of flowers 72 hours and beyond after anthesis.

Disinfectant	Parts of the flower.	Botrytis	Cladosporium	Fusarium.	Pestalotia.	Sterile Mycelium.	Other Fungi
$HgCl_2$	Petals	88	74	63	42	6	63
	Stamens	100	68	54	49	3	73
	Styles	94	92	72	28	2	68
	Calyx	3	2	Nil	32	78	4
CaOCl.Cl	Petals	82	64	68	52	3	72
	Stamens	100	72	60	50	6	70
	Styles	92	97	70	24	Nil	74
	Calyx	2	4	1	39	83	3

This dematiaceous mycelium from the calyx is very slow-growing in culture, pale brown at first, becoming deep brownish black. It has tiny sclerotia simulating those of many *Sphaeropsidales*. In plates which were kept for well over 6

weeks, fructifications of *Gloeosporium*, *Glomerella* sp., *Physalospora* sp., *Pullularia pullulans* and an unidentified hyalosporus coelomycete were observed. These fungi never occurred singly but were always present in associations of 2 to 5. Their ability to infect Tea flowers has not been investigated yet.

Botrytis was observed in 2% of stamens plated from flowers 12—24 hours after anthesis (Table 12, Text Fig. 1). In view of considerable difficulties encountered in sterilizing and plating out stamens, it is believed that *Botrytis* might have come in as a contaminant or due to improper surface sterilization. It was not unusual to find *Botrytis* in the nutrient agar plates along the inner edges of the Petri plates suggesting that it might be an aerial contaminant. In flowers 24—48 hours after anthesis, *Botrytis* was observed emerging out of petals, stamens and styles in both the disinfectant treatments (Table 13), stamens yielding the highest percentage followed by petals and style. Calyx was free from *Botrytis*. However, the sterile mycelium from the calyx also showed a corresponding increase in the percentage occurrence (Text Fig. 5).

Following 48 hours after anthesis (Tables 14 and 15), an explosive increase in the percentage occurrence of *Botrytis* was seen in petals, stamens and styles, stamens registering always the highest percentage. It is interesting to observe that there is a corresponding increase in the occurrence of *Cladosporium*, *Fusarium*, *Pestalotia* and other fungi like, *Pullularia*, *Gloeosporium*, *Papularia*, *Cylidrocladium*, *Arthrinium*, *Aspergillus*, *Penicillium*, *Paecilomyces*, *Helminthosporium*, *Curvularia*, *Periconia*, *Memnoniella*, *Stachybotrys*, *Alternaria*, *Zygosporium*, *Nigrospora*, *Thozetellopsis* Gen. nov. etc. (Text Figs 2 to 6).

It is likely that all these various fungi appear on tea flowers in an ecological succession in which *Botrytis*, *Cladosporium*, *Fusarium* and *Pestalotia* are primary (pioneer) colonizers of a declining (freshly exposed) substratum. This is supported by the fact that *Botrytis* was not isolated either from the ovary or calyx of flowers found attached to the plant.

BIOCHEMICAL BRANCH

D. J. Wood—Senior Biochemist
N. B. Chanda—Biochemist

STAFF

Mr. D. J. Wood announced his resignation in September and is leaving in April 1958. Dr. I. S. Bhatia has been appointed Senior Biochemist.

RESEARCH AND EXPERIMENT

Fundamental Research

Chemical Differentiation of Tea Varieties:

During the past few years large numbers of samples have been examined with a view to establishing relationships between chemical composition and morphological features of the tea bush. The technique used has been two-dimensional paper chromatography of leaf extracts and the chemicals studied have been chiefly the phenolic substances, many of which were formerly included under the misleading name "tea tannin". This work has been done in collaboration with the London Laboratory. It is based upon taxa proposed by the Senior Botanist (Dr. W. Wight). The chemicals studied are in close agreement with Wight's system of classification. A technical paper giving the results of this joint research is about to be published in the New Phytologist.

The chemicals concerned are not changed during manufacture and can be detected equally well in made tea. Thus by examining a sample of made tea it is possible to give a definition of the bush from which the tea was manufactured. This is likely to have many practical applications.

The study has been extended to cover species other than tea. There is no chance of confusing tea with any of the species examined, and provided suitable material is available tea can be positively identified by means of its chromatogram. A specimen of presumed tea sent by F. Kingdon-Ward from Burma was shown to resemble chromatographically the F_1 hybrids produced experimentally by crossing tea with a closely related Camellia. Parallel botanical examination confirmed the identity of this specimen, the occurrence of which in the

wild state is of considerable interest. A joint paper on the subject is being published in Nature.

Chemical Basis of Quality :

The broad aim of this project is to find out which ingredients of leaf and made tea are important in determining liquor characters. The study at present is confined to a comparison of various clones, *jats* and experimental progenies known or believed to differ in quality.

The project was commenced in 1956, and from the results for four *jats* it appeared that a high content of water-soluble solids, total polyphenol and caffeine was a desirable feature of the fresh leaf and that a highly active oxidising enzyme was important in the development of colour and strength. In the made tea a high content of theaflavins and perhaps also of thearubigins (two groups of oxidised polyphenols) appeared to be desirable.

In 1957 the study was extended to cover nine sources of leaf comprising three vegetative clones, the progenies of three experimental matings and three stocks raised from bulk seed. As it was not possible to analyse and manufacture nine samples on a single day they were divided into two groups which were plucked on different days of the week. The following is a brief description of the sources comprising the two groups:

Group I

Stock 257	Seed collected in the Lushai Hills.
Clone 20/17/5	Tocklai vegetative clone.
Gaurisankar, Dranjuk, Landikotal	Three separate progenies of experimental matings.

Group II

Clone 20/23/1	Tocklai vegetative clone.
Clone 1/7/1	Tockial vegetative clone.
Stock 248	Seed collected in Burma.
Stock 252	Seed from a flavoury section of a Darjeeling garden.

The leaf was plucked at weekly intervals, but it was only possible to conduct the full range of chemical analysis each fortnight, and on these occasions manufacture was by the orthodox two-roll system. Observations early in the season had suggested that a Taster's order of preference for a range of

samples after C. T. C. manufacture might not be the same as his order after orthodox manufacture, so opportunity was taken of manufacturing the leaf in the intermediate weeks by the C.T.C. process ; on these occasions chemical examination of the leaf was not possible and only very limited analysis of the teas could be undertaken. Samples of all the teas, both orthodox and C.T.C., were distributed to our usual Tasters under code markings ; the Tasters were asked to report on the separate characters of the liquor and to give purely nominal comparative valuations without looking at the dry leaf.

The results for Group I are complicated by the fact that the three opinions on liquor characters (Tocklai Taster, Calcutta Panel and London Panel) disagreed considerably. Rather than give the three separate opinions only the Tocklai Taster's marks are shown in Table 1 and mention is made below of the major points of difference. Also included in Table 1 are figures for some of the more important chemical ingredients, both leaf and tea.

Table 1:

	Sample	257	20/17/5	GAUR	DJK	LNDK
Fresh Leaf	Soluble Solids	50 2	49·8	49·7	49·4	47·4
	Total Polyphenol	34 0	33·9	33·5	32·9	31·2
	Qo_2	22·4	21·6	20·3	20·8	21·0
	Qo_2 × Polyphenol	762	733	680	685	656
	Caffeine	4·54	4·09	4·09	4·02	4·45
Made Tea Orthodox	Theaflavins	·234	·262	·198	·236	·219
	Thearubigins	1 285	1·348	1·206	1·352	1·556
	Distr. Coefficient	·418	·456	·422	·446	·385
Taster's Marks Orthodox	Colour	53	53	50	58	67
	Strength	62	55	50	60	66
	Quality	2	55	50	37	40
	Briskness	66	55	50	58	47
	Valuation (Rs.)	1·98	2·50	2·42	2·33	2·37
Made Tea C.T.C.	Theaflavins	·482	·503	·379	·404	·370
	Thearubigins	2·333	2·385	2·165	2·276	2·273
	Distr. Coefficient	·463	·487	·472	·478	·435
Taster's Marks C.T.C.	Colour	45	55	50	55	44
	Strength	52	56	50	56	49
	Quality	4	61	50	45	36
	Briskness	65	59	50	53	46
	Valuation (Rs.)	3·00	3·60	3·48	3·42	3·29

It will be noted that the liquor marks for Gaurisankar are in all cases 50. This is because Gaurisankar was chosen, arbitrarily, as the "standard" with which the other samples were to be compared and automatically allotted 50 marks; marking of the other samples is relative to this standard on a scale of 0 to 100.

Valuations received from the Calcutta and London Panels showed that they agreed with the Tocklai Taster that 20/17/5 and Gaurisankar were better teas than Dranjuk and Landikotal, although their marks for individual characters differed not only from his but also from each other's. However the quality of Stock 257 and its valuation were the subject of very serious disagreement. It will be seen that the Tocklai Taster gave an exceptionally low mark for quality to this tea and considered it easily the worst tea of the five. He described it on every occasion as "coarse and metallic", and observation showed that his dislike of this tea was due to a most peculiar and powerful aroma, particularly noticeable during fermentation, which was quite unlike that usually associated with tea. The Calcutta Panel gave this sample the highest marks for quality and the top valuation, commenting on its fine flavour, but did admit on one occasion that the members of the Panel were divided in their opinion. The London Panel on average gave it an intermediate mark for quality, but were most inconsistent, examination of their reports week by week showing that they nearly always placed it either top or bottom. There is no doubt that the aroma referred to above gives this tea an unusual character which some Tasters find hard to place. To give a broader idea of the general opinion concerning this character a number of other Tasters were consulted, and in every case they agreed with the Tocklai Taster's dislike of Stock 257 though not always to quite such a pronounced degree.

Statistical analysis shows that colour is positively correlated with thearubigins in the orthodox teas. No other significant correlations have so far been established. Colour and strength are clearly not correlated with Qo_2 x Polyphenol, although for the four *jats* examined in 1956 this correlation was very highly significant. It is perhaps fair to omit Stock 257 when consider-

ing quality, as the inferior quality of this sample is clearly due to substances not shown in Table 1, and when this is done the quality, and the valuation, of the other four teas after C.T.C. manufacture follow the same order as the figures for soluble solids and total polyphenol ; the correlation with polyphenol is significant.

The results for the Group II teas are shown in Table 2. Again only the Tocklai Taster's liquor marks are included. The "standard" sample is clone 1/7/1.

Table 2:

Sample		20/23/1	1/7/1	248	252
Fresh Leaf	Soluble Solids	50·9	52 5	49·2	46·2
	Total Polyphenol	36·5	37·0	32·6	28·1
	Qo_2	23·6	18·4	20·6	18·0
	Qo_2 × Polyphenol	863	681	672	506
	Caffeine	4·58	4·30	3·95	3·57
Made Tea Orthodox	Theaflavins	·247	·175	·190	·163
	Thearubigins	1·309	1·145	1·142	1·251
	Distr. Coefficient	·444	·364	·416	·378
Taster's Marks Orthodox	Colour	58	50	43	55
	Strength	53	50	42	44
	Quality	51	50	34	5
	Briskness	63	50	38	30
	Valuation (Rs.)	2·48	2·50	2·25	1·77
Made Tea C.T.C.	Theaflavins	·524	·387	·361	·296
	Thearubigins	2·405	2·353	2·191	1·959
	Distr. Coefficient	·512	·438	·458	·449
Taster's Marks C.T.C.	Colour	53	50	28	12
	Strength	61	50	38	24
	Quality	54	50	25	1
	Briskness	62	50	38	29
	Valuation (Rs.)	3·74	3·70	3·18	2·14

Agreement between Tasters was much better in the case of the Group II teas. The only major disagreements were that in the orthodox teas both Panels gave Stock 252 a much

lower mark for colour, and the Calcutta Panel considered this same sample to be very slightly better than Burma both in quality and valuation; in the C. T. C. teas the London Panel preferred 1/7/1 to 20/23/1 for strength, quality and valuation.

Stock 252 was another sample with distinctive aroma, in this case the aroma always associated with the China kind of tea bush. The Tocklai Taster dislikes this character, which partly accounts for his low marks for quality. The Calcutta Panel are evidently not quite so averse to it, and on one occasion during the second flush, when this character would be expected to be more fully developed and possibly reminiscent of Darjeeling flavour, they gave Stock 252 the top marks for quality.

A number of the correlations which were established in 1956 also hold good for the Group II teas. Strength is correlated with Qo_2 x Polyphenol, but only after C.T.C. manufacture. Likewise strength and briskness are correlated with theaflavins, and colour and strength are correlated with thearubigins, but again only after C.T.C. manufacture. Quality and briskness are correlated with caffeine in both types of manufacture.

Considering the two groups together it is clear that the effect of C.T.C. manufacture relative to the effect of orthodox manufacture is not the same for all samples. Table 3 shows the ratio of certain figures in the C.T.C. teas to the equivalent figures in the orthodox teas, the figures chosen being those for valuation, theaflavin content and thearubigin content.

Table 3:

Sample	Valuation Ratio	Theaflavin Ratio	Thearubigin Ratio
20/23/1	1·51	2·12	1·84
257	1·51	2·06	1·82
1/7/1	1·48	2·21	2·05
Dranjuk	1·47	1·71	1·68
20/17/5	1·44	1·92	1·77
Gaurisankar	1·44	1·91	1·79
248	1·41	1·90	1·92
Landikotal	1·39	1·69	1·46
252	1·21	1·81	1·58

The Tocklai Taster's valuation ratios are to a large extent borne out by the theaflavin ratios. The practical outcome of this is of some importance, as it means that certain kinds of bush are relatively more suited to C.T.C. manufacture than others. Based on one's knowledge of their behaviour in orthodox manufacture some kinds give better tea than expected as a result of C.T.C. treatment while others give worse. The figures for Stock 252, which is characteristic of much of the so-called "China" tea growing in Darjeeling, suggest that C.T.C. manufacture in that district might well give most disappointing results.

The explanation for this difference in relative effect of C.T.C. treatment is not at once apparent. However from our knowledge of the chemical mechanism of fermentation the content of theaflavins and thearubigins in the C.T.C. teas is more what one would expect than their content in the orthodox teas, given the fresh leaf ingredients shown in Tables 1 and 2. For instance it is hard to interpret the very high thearubigin content of the Landikotal orthodox sample bearing in mind its low figure for total polyphenol ; similarly Stock 252 has a much higher content of thearubigins after orthodox manufacture than one would expect, though not after C.T.C.

The simplest assumption to account for these observations is that in orthodox manufacture the shoots from some kinds of bush are physically more resistant to damage than others, and that in the resistant kinds a greater percentage of polyphenol remains unoxidised ; but that hard C.T.C. treatment, by its very drastic mechanical effect, brings about virtually complete cell damage no matter what kind of bush the shoots come from.

We are indebted to the Senior Botanist for pointing out that the valuation ratios in Table 3 are a function of Phloem Index. This means that if the Phloem Index of a bush or population is known the valuation ratio can be predicted.

Reviewing the results of the past two years' experiments it is possible to form some sort of picture of the knowledge gained. The rather striking correlations between liquor marks and chemical ingredients obtained in 1956 do not apply in all cases. This was predicted in the 1956 Annual Report where it was

suggested that the true picture was likely to be more complicated. A high content of total polyphenol (and with it of course a high soluble solid content) is a desirable attribute; so also is a high Qo_2, which is a measure of the activity of the oxidising enzyme. This much was known already and is fully confirmed. The case for caffeine is a little less certain and will require more data. In some instances it is positively correlated with liquor marks, including quality, but in those instances the caffeine content runs very nearly parallel with the polyphenol content which makes it just possible that the correlation between caffeine and liquor marks is fortuitous. The work of the London laboratory has shown that theaflavins and thearubigins are of very great importance in determining the liquoring properties of commercial teas. Our own results show that where individual *jats*, clones etc. are manufactured, particularly by the orthodox system, their content of these substances does not always indicate their value as a liquor. The orthodox teas made from Gaurisankar and clone 1/7/1 are examples of very fine teas with a low content of theaflavins and thearubigins. Clearly there is something about the liquors of these two teas which Tasters like, but just what it is not possible to say. It could well be their "character", determined by essential oils. Poor liquors are frequently, perhaps usually, due to a low polyphenol content in the fresh leaf and a rather low enzyme activity, as typified by Stock 252 and by Area 36 (reported in 1956); though it should be noted that Stock 252 grown in Darjeeling develops a flavour which far outweighs its lack of other ingredients. Stock 257 is a rather striking example of a tea which is poor for quite another reason, namely because it contains an undesirable volatile ingredient. Its figures for soluble solids, polyphenol, Qo_2 and caffeine are all high, and but for its aroma it might easily make a very fine tea. This is the first example of such a case which has come to our notice.

To sum up, we are still only able to make rather generalised statements about the chemical interpretation of liquor characters and much remains to be found out. Ingredients other than the obvious ones play their part, some in a positive and others in a negative direction. The amount of cell damage brought about by orthodox rolling appears to depend on the kind of bush and to be related to Phloem Index.

The Volatile Constituents of Tea :

Work on this subject has consisted mainly of attempts to improve the technique both of the initial extraction of volatile matter from leaf or tea and of its subsequent chemical examination, usually by chromatographic methods. These improvements were necessitated by the failure of the methods previously tried to give dependable results and by the evident losses in volatile matter which were being experienced. It is believed that some of the modifications which have been made do represent a definite improvement ; in the meantime little has been added to our knowledge concerning the nature of the volatile ingredients.

That they play an important part in determining a tea's quality, sometimes having an adverse effect, is shown by the results above under the heading "Chemical Basis of Quality". Further evidence has been obtained by taking note of the aromas, during fermentation, of a large number of individual bushes and comparing them with the Tea Taster's subsequent reports on the samples. The number of different aromas which can be distinguished is very large ; so also is the variation in their apparent intensities, the aroma of some bushes being most pronounced, that of others hardly noticeable. Certain types of aroma were found to be associated with the Tocklai Taster's description "metallic"; another type was associated with remarks such as "sweaty" and "cabbagy". One class of aroma, rather suggestive of "oil of Wintergreen" to this particular observer, was frequently associated with a high mark for quality. There can be no doubt that aroma, as well as taste, is included in the term "quality" as used by the Taster, and until the volatile substances responsible for aroma have been fully investigated an important aspect of quality must remain something of a mystery.

Darjeeling Flavour : Dependence on Kind of Bush :

Planters in the Darjeeling district distinguish three main kinds of tea: "China", "China hybrid" and "Assam". The first two account for a very large proportion of the crop, whereas the third is much less widely grown and in most cases is of comparatively recent introduction. Some are in favour of increasing the proportion of Assam tea in the belief that crop

per acre will be improved thereby. However crop is not the only consideration ; selling price of the tea is equally important, and unless the product of the two, i.e. crop x price, is increased the economics of the district will not be improved. The value of a Darjeeling tea is tied up to a large extent with its distinctive character, usually referred to as "Darjeeling flavour". It is therefore most important to know how Assam tea stands in respect of this flavour when compared with China and China hybrid tea grown at equivalent elevations.

A number of opinions, some widely divergent, have been expressed on the subject. For instance it has been stated, in answer to questions put by Tocklai staff, that Assam tea gives just as much flavour as China, though there may be many who would disagree with this. A variation of this opinion is that Assam is better at some seasons, while China is better at others. One belief is that Assam bushes are devoid of flavour when immature, but that they acquire this character as a result of many years existence in the Darjeeling district. Or again it has been said that the difference in flavour between China and Assam depends on the elevation at which they are grown.

Experimental evidence for any of these views appeared to be lacking, and it was decided at Tocklai in 1955 to initiate an investigation which would give definite information on some or all of these various points. The investigation was done in collaboration with certain estates in Darjeeling who were requested to manufacture, at stated times of the year, leaf from a China or China hybrid section and simultaneously leaf from an Assam section, and to send samples of both to Tocklai.

For the seasons 1955 and 1956 the results of the investigation were inconclusive, partly due to lack of agreement among tasters, partly due to the small number of estates participating. In 1957 a more determined effort was made involving eight estates, and reports received from the various tasters were in much better agreement. Inspection of the sections concerned at the beginning of the season showed that in some cases the so-called "Assam" tea was in fact very mixed, containing many bushes with obvious China affinities. Sections of this type fell naturally into a fourth group, referred to by us as "hybrid Assam".

It is not proposed to give here the results in full, but rather to state the conclusions which we are able to draw. The results in full have been communicated to the estates concerned, the President of the Darjeeling Branch I. T. A., and Agency Houses with interests in Darjeeling.

The conclusions are that flavour is most fully developed in "China" tea, and that it decreases progressively in the order "China hybrid", "hybrid Assam", "Assam", the latter having only poorly developed flavour. This order holds good at all the elevations investigated (which extended from 3,000 ft. to 5,500 ft.) and at all seasons of the year, though there are indications that the differences may be rather more pronounced in the second flush and rather less pronounced during the rainy season. The flavour of an Assam *jat* is not enhanced by age.

It will be apparent that these findings cast serious doubt on the wisdom of planting "Assam" kinds of bush in the Darjeeling district. Tasters' valuations indicated that although tea manufactured from "Assam" sections might be preferable in some respects, notably in tip content, this was not sufficient to outweigh its comparative lack of flavour, and in 87% of cases the sample with more flavour also received the higher valuation.

In case the above statements should be used as a basis for bush selection in vegetative propagation it is necessary to add one final word by way of qualification. Throughout the so-called "China" tea of the Darjeeling district, and in hybrids thereof, there is evidence of a number of "foreign" elements not found in the true China variety of the tea plant, some of them possibly originating from other species of Camellia. From studies not connected with the present experiment it seems likely that *full* development of flavour requires a certain measure of some "foreign" element in addition to a high incidence of China characters. When whole sections of tea in the Darjeeling district are considered this requirement is normally satisfied. But when one comes down to the level of the individual bush the intensity of these different sets of characters is seen to vary independently, and the best flavour is not necessarily to be found in individual bushes with the most pronounced China characters.

Manufacturing Experiments

Tobacco-Cut Manufacture: Standard of Plucking:

An opinion which appears to be held by a certain section of the planting community in the Dooars is that in non-wither tobacco-cut manufacture inclusion of the coarser portions of the shoot is essential for the production of good liquoring teas, and that fine plucking is in consequence a mistake. It was decided to test this rather unusual idea by carrying out a simple *ad hoc* experiment, in spite of the fact that it does not seem possible from a theoretical consideration.

The leaf was from Area 15A, Borbhetta, planted with bushes generally similar to much of the tea in the Dooars. The area was divided into three blocks which were plucked in such a way that, on the same day each alternate week, they yielded seven-day leaf, ten-day leaf and fourteen-day leaf, plucking in all cases being "black". Table 4 shows details of the shoot count (average of the whole experiment).

Table 4:

	7-Day Round	10-Day Round	14-Day Round
% 1 + Bud	6	2	1
% 2 + Bud	61	23	15
% 3 + Bud	23	38	35
% 4 + Bud	0	18	24
% 5 + Bud	0	1	3
% Banji	10	18	22
Weight of 100 shoots	68 gm.	119 gm.	155 gm.

The three portions, without withering, were manufactured identically by the tobacco-cut process. The fired tea from each treatment was sorted into a bulk grade from which samples were distributed to our usual Tasters. Their reports, on infused leaf and liquors only, were submitted on our standard Tasting Form and they were requested to give nominal comparative valuations based on these characters only without taking the dry leaf into

consideration at all. The experiment was carried out on nine occasions (three in the Second Flush and six in the Rains). Table 5 shows each Taster's average marks for the whole experiment.

Table 5:

	7-Day Round	10-Day Round	14-Day Round
Tocklai Taster.			
Infused Leaf	64	44	42
Colour	46	52	57
Strength	47	54	71
Quality	69	46	34
Briskness	60	48	46
Valuation (Rs.)	2/19	2/07	1/89
Calcutta Panel.			
Infused Leaf	67	46	37
Colour	60	43	46
Strength	67	46	38
Quality	68	46	37
Briskness	70	44	37
Valuation (Rs.)	3/08	2/71	2/53
London Panel.			
Infused Leaf	63	40	33
Colour	60	34	34
Strength	61	39	34
Quality	62	40	31
Briskness	64	40	31
Valuation (sterling)	5/9	4/9	4/5

All Tasters agree that, considering the liquor as a whole, the best tea is that made from seven-day leaf and the worst is that made from fourteen-day leaf. The Calcutta and London Panels give substantially the same order of preference to all the individual attributes, so that the ten-day and fourteen-day leaf compare most unfavourably with the seven-day leaf in all respects. The Tocklai Taster, however, differentiates sharply between colour and strength on the one hand and quality and briskness on the other. According to his opinions colour and strength actually improve with coarser plucking; but this improvement is more than offset by the decrease in quality and briskness as can be seen from his valuations.

The only conclusion which can be drawn from this experiment is that, in the tobacco-cut system as in other forms of manufacture, the finer the plucking the better the liquor. The belief that for tobacco-cut manufacture there is some special virtue in the coarser portions of the shoot is not borne out.

SCIENTIFIC PUBLICATIONS

The following scientific papers were accepted for publication:

Roberts, E. A. H., Wight, W., and Wood, D. J. Paper chromatography as an aid to the taxonomy of Thea Camellias. *New Phytol.* (*in the press*).

Wood, D. J., and Barua, P. K. Species hybrids of tea. *Nature*. (*in the press*).

Chanda, N. B. Murexide test in paper chromatography. *Nature*; (*in the press*).

ADVISORY

Advisory Correspondence.— During the year 106 letters of an advisory nature were issued.

Touring.— The Senior Biochemist visited 12 gardens, either to give advice on manufacture or to carry out experiments.

BIOCHEMICAL BRANCH— TEA TASTING SECTION

J. M. TRINICK—Tea Taster.

STAFF

No changes took place in the staff during 1957.

TASTING

During the year the following samples were tasted:

For Tocklai Experimental Station ...	2,855
For member estates	4,937
For non-member estates	101
	7,893

ADVISORY

Touring.— The Taster visited the following estates in connection with manufacture:

Assam member estates:

Cinnamara, Mohokutie, Suntok, Gelakey, Mackeypore, Hunwal, Koomtai, Cherideo, Purbut, Sycotta, Woka, Hautley, Duamara, Dhoolie, Nagajanka, Doyang, Rajmai, Sangsua, Naganijan and Dessoie.

Assam Non-member estates:

Lukwah.

Cachar member estates:

Kallinecherra, Isa Bheel, Koomber, Chandighat, West Jalinga, Longai, Kunchunpore, Aenakhall, Burtoll, Silcoorie, Binnakandy and Burnie Braes.

Darjeeling member estates:

Nagri Farm, Ging, Tumsong, Badamtam and Tukvar.

Courses.— The Taster gave three lectures on tea manufacture at the three general courses held during February and March. Two lectures on miniature manufacture were given at the two clonal courses held in May.

Advisory Correspondence.– 491 letters of an advisory nature were issued during the year.

Advisory Publications.— A report covering tea manufacture in Cachar was written by the Taster for the Cachar Quarterly dated March 1957.

GENERAL REMARKS.

The Taster personally assisted the Senior Research Engineer in conducting commercial trials with the Continuous Roller No. 1.

ENGINEERING DEVELOPMENT BRANCH

I. McTear—Senior Research Engineer

D. N. Borbora—Assistant Engineer

STAFF

Mr. I. McTear returned from overseas leave on the 23rd March. Mr. D. N. Borbora proceeded on one month's leave on the 9th December.

RESEARCH AND EXPERIMENT.

Mechanical Harvesting :

Field experiments with the mechanical harvesting machine were continued during the year at Borbhetta in Area 6, as in previous years.

The experiment was designed to give the following comparisons :—

(I) Rows 'A'—Hand pruned and subsequently hand plucked from an 8″ tipping level on a 7 day round.

(II) Rows 'B'—Machine pruned and subsequently machine harvested from an 8″ tipping level at a 7 day frequency.

(III) Rows 'C'—Machine pruned and subsequently machine harvested from a 4″ tipping level at a 7 day frequency.

Tea is planted $4' - 0'' \times 4' - 0''$ and is unshaded. Each treatment comprises 8 rows of 100 tea bushes.

In a comparison of this nature it is inevitable that the new method (i.e. machine harvesting) must result in inferior overall results compared with hand methods primarily because of machine modifications which must of necessity take place during the experimental phase and therefore have some bearing on growth reaction. However it can be said with certainty that a mechanical harvester must fulfil three essential functions :—

(i) Remove all mature growth above the predetermined harvesting level.

(ii) Reject as far as practicable all immature shoots.

(iii) Should not subject harvested leaf to mechanical damage.

In further explanation of the above three main essentials, it might be added that:—

(i) Failure to remove all mature growth during a particular harvesting round means that the percentage and nature of coarse leaf in the following round will be intensified. Also new growth points are reduced in number with consequent loss in crop.

(ii) There can be no sure aid in regard to a mechanically propelled vehicle which will effect 100% rejection of immature shoots, since mature shoots which happen to be in close proximity to the immature ones have a bull-dozing effect as the feed-paddle plus the forward momentum of the vehicle directs the mature shoots into the cutting mechanism, so that a combination of these factors to some extent outweighs the fitment designed for rejection of immature shoots. Increased density of the 'flush' is another contributory factor in this same connection. However in consideration of these unavoidable drawbacks the rejection of immature growth by means of the two-way adjustable rejection bar below the cutting knife is of a satisfactory order.

(iii) It will be agreed that mechanical damage to harvested leaf should be avoided at all costs. This aspect of the action of the mechanism has been under constant attention and by gradual elimination of factors responsible for damage to leaf the current position in this respect is also satisfactory.

It is interesting to compare results between Rows 'B' and Rows 'C'. Rows 'B' were tipped to 8″ but the harvesting level was maintained for 14 rounds then raised 5/8″ (27th August '57) and was retained at this level for a further 6 rounds (i.e. until 21/10/57) and for each of the remaining rounds was raised $\frac{1}{4}$″.

A combination of the 8″ tipping level and retention of harvesting level was undoubtedly responsible for the significant drop in yield as well as the significant increase in unmanufacturable leaf.

Remarking upon the growth reaction in Rows 'B', this at no time during the season could be said to compare favourably with Rows 'C' (4″ tipping level) since the bushes lacked compactness at harvesting level and were 'open' to the extent that branches yielded easily to the motion of the machine as well as to moderate winds. This resulted in coarse leaf from side branches being easily disturbed and so coming into contact with the cropping mechanism with inevitable results. Perhaps this accounted in no small measure for retarded growth response.

As the season progressed the effect of maintaining a constant harvesting level in Rows 'B' became manifest. The repeated rubbing action of the metal parts of the machine on the cut shoots caused damage to the shoots and ultimate die-back of stems was much in evidence. To counter this the subsequent harvesting levels were raised each round by $\frac{1}{4}$″ and this had the effect of inducing new growth in the damaged stems. Unfortunately the season was drawing to a close and growth considerably slowed down in consequence. However this experience points directly to the necessity for raising the harvesting level as frequently as possible so that this mechanical damage is minimised.

Compared with Rows 'A' (hand plucked) Rows 'C' did not show any significant difference in total yield (coarse leaf ignored). The 4″ tipping level resulted in a more solid harvesting table and was, compared with Rows 'B', considerably less yieldable to disturbances such as resulted from machine motion and wind. In consequence the efficiency of the cropping mechanism was more effective due to increased denseness of the bushes whilst the growth habit of the old coarse leaves was appreciably more inclined to the horizontal than was the case in either Rows 'A' and 'B' (both at 8″ tipping level). This appeared to result from the lack of branch support given to coarse leaves in Rows 'C' when compared with the extra length of the branches resulting from the 8″ tipping levels.

The significance of the amount of coarse leaf resulting from the different treatments between Rows 'B' and 'C' will be seen from the following percentages realised during the full growing season. Row 'B' was 17.32% and Row 'C' 11.12% unmanufacturable leaf.

Unless there are good reasons for introducing modifications to the machine during the coming season it is intended that the machine will work in its current form so that the cultural reactions may be more closely co-ordinated to the effects of mechanical harvesting without introducing factors which can disturb these observations.

The mechanical harvester, as at present operating, reasonably fulfils the majority of the requirements discussed and it is felt that with the experiences of the season just concluded more useful information can be gained from working the machine in such a manner that damage to the cut shoots is reduced to a minimum which implies frequent raising of the harvesting head and possible reduction in the frequency of the machine harvesting rounds when compared with the standard set by hand plucking methods.

Machine Pruning:

In conjunction with the mechanical harvesting of leaf Rows 'B' and 'C' were mechanically pruned. Rows 'A' were hand pruned in accordance with established practices.

The mechanical pruning head is unaltered from the previous season's working as it has been found to give satisfactory results in tea planted 4′-0″ × 4′-0″.

There can be no doubt that hedge planted tea is more suited to mechanical harvesting and pruning. Apart from the increase in the number of bushes dealt with for a given ground speed, which is constant regardless of spacing of bushes, the additional firmness inherent in the closer spacing improves the quality of the work the machine does, and may conceivably result in less bruising of the freshly cut shoots due to the more solid nature

of the tops of the bushes as distinct from the branch "springiness" obtaining in bushes of wider spacing.

Controlled Withering :

The object of withering leaf is to render it physically suitable for subsequent processing as well as to bring about the biochemical change. In another sense the object of controlled withering is to wither physically the maximum amount of leaf in the shortest time possible in the minimum space regardless of prevailing atmospheric conditions.

The bulkiness of tea in the fresh green leaf state presents many problems the greatest of which, from a manufacturing point of view, is that of handling.

The ideal in withering leaf is a uniform bed of leaf thinly spread but since this is not an economical practical proposition, particularly in the case of controlled withering installations where capital cost of plant has to be considered, a suitable compromise is necessary.

It has been shown during Tocklai experiments into controlled withering that very good average results can be obtained with leaf spread at 4.00 lbs. per square yard. Even at this density of spreading handling cannot be dismissed as anything but laborious.

With a view to reducing handling of leaf to reasonable proportions tests of a limited nature have been undertaken with leaf spread at 8.00 lbs. per square yard of tray area. This quantity of leaf it may be noted, is almost equivalent to an area of 9 square yards as deemed desirable for natural wither spreading. It cannot be denied that this rate of spread (8.00 lbs./sq.yd.) is an attractive proposition from many points of view. There is however a variation in percentage wither within the bed of leaf.

Leaf spread at 8.00 lbs. per square yard results in a bed of leaf approximately $3\frac{1}{2}$ inches thick. As wither proceeds the leaf suffers partial collapse and the extra weight of leaf at this

thickness further assists towards this end. As this collapse progresses during the course of withering the free space for air flow also increases so that withering efficiency falls somewhat compared with tests conducted during 1955 at 4.0 lbs./sq.yd. However it was found that the overall wither obtained was closely allied to the 3.50/4.00 lbs./sq.yd. rate of spread.

The variation in wither percentage from tray to tray was very similar to previous results but within the bed of leaf the extreme middle showed reduced loss of moisture compared with top and lower leaf layers.

The question which arises is whether this variation has an overall effect on the teas manufactured. Due to the curtailed nature of the tests results are inconclusive. Certainly the Taster who dealt with these teas in competition with similar percentage naturally withered leaf found some difficulty in awarding a preference to the natural wither.

There is a factor involved in the manufacture of leaf of the above nature which has been withered in a Tunnel or a continuous withering machine which no doubt considerably cancels out the discrepancy in withering: the leaf is freely mixed during rolling and so a transfer of moisture takes place from the greater to the lesser moisture containing leaves. There is no comparable method of achieving this mixing in the case of natural withers which must be manufactured as taken from a particular chung structure regardless of any wither difference prevailing in the other buildings.

Continuous Rollers:

The machine previously referred to as machine No. I (Tubular) has now been designated the "Rotorvane" continuous processing machine.

In its current form this machine is fitted with an automatic pressure creating device attached to the discharge mouth of the cylinder as well as a mechanical feed coupled to the machine action.

Development of this machine has concerned three methods of manufacture as follows:—

(*i*) *Orthodox Manufacture*:

Processing once-rolled leaf after extraction of 'fines', or all leaf, if tip and leaf grades are of secondary importance.

(*ii*) *C.T.C. Manufacture*:

Conditioning withered leaf for subsequent C.T.C. process. This reduces the time the leaf is in the Rolling room to about 5 minutes. Fermentation timing will of course be uniform from the start to close of manufacture.

(*iii*) *Legg-Cut or Non-Wither Manufacture*:

To process leaf after cutting in place of the conventional cone roller process. Both machines (Legg and "Rotorvane") being continuously operating types makes co-operation between them a simple matter. As in the case of C.T.C. manufacture the duration of the process from the start of cutting is about 5 minutes.

As continuous operation is the primary function of the "Rotorvane" it was essential to test the machine under conditions similar to those in which it would eventually operate. The limitations arising at Tocklai, whilst sufficient for fixing certain basic information, could not provide the essential feature of continuity of feed and so the machine was installed in a commercial factory towards the end of October 1957 where it operated in conjunction with conventional once-rolled leaf. These tests gave much valuable information in that the character of processing was quite different compared with that experienced at Tocklai with limited feed facilities. Thus at the close of the season necessary modifications to the machine designed to increase the effectiveness of processing were carried out.

The " Rotorvane " continuous processing machine will not produce whole leaf grades since the action of the machine is somewhat vigorous.

Continuous Roller No. 2 (as yet un-named) is altogether different and has been designed and developed with a view to producing conventional teas. Indications are that it produces rather more tip than orthodox three-crank rollers. The time taken to pass from feed to discharge is about 4 minutes thus permitting green leaf sifting for extraction of 'fines' before the bud is damaged to the extent that tip is destroyed. It is perhaps this special feature as distinct from orthodox conventional rollers 30 minute processing which accounts for tip preservation.

Conditioning leaf for C.T.C. process is a convenient operation in this machine because both machines are essentially continuously operating types. Tests have shown that this combination compares favourably with orthodox 20-30 minute conditioning roll in three-crank rollers. Time for processing leaf for this purpose in the Continuous Roller No. 2 being 4 minutes.

This machine is still undergoing development to meet the rather exacting requirements of conventional teas but it is nevertheless considered that it will successfully fulfil these duties after a further short period of development.

Fermentation :

The measurement of heat generated during fermentation has been under study at various times during the past season in an attempt to evaluate the amount and nature of heat.

It has been found that mere recording of the temperature rise by a thermometer placed in a bed of fermenting leaf presents an erroneous picture of the process involved on account of modifying influences of the atmosphere in the fermenting room as well as the nature of the fermenting floor or surface and the voids in the bed of fermenting leaf which expose large areas of leaf surfaces to the atmosphere so assisting dissipation of heat. To offset these, calorimetric determinations by means

of a bomb-calorimeter were made. Total heat evolved by fermenting leaf etc. during the period was obtained after making necessary corrections. Three different sets of experiments were conducted for three standard methods of manufacture:—

(1) Unwithered Legg-Cut manufacture.
(2) Conventional Two-roll manufacture.
(3) C.T.C. manufacture with conventional pre-roll.

Observations to date indicate that total heat of fermentation is dependent on:—

(1) Nature and quality of leaf.
(2) Pressure and load applied during rolling.
(3) Degree of wither or moisture content of the leaf.
(4) The atmosphere of the rolling and fermenting rooms.
(5) Thickness of spread on fermenting surfaces.

Evolution of heat has been observed to be gradual and continues throughout the period of fermentation normally accepted for the type of manufacture and in most cases the rate of evolution of heat is comparatively slower during the early part than that towards the later part of the fermentation period. It has also been observed that clonal leaf samples generally, show a higher rate of heat evolution than bulk leaf samples.

Investigations will be continued next season.

Drying :

A prototype drying chamber has been constructed based on the principles employed in the continuous withering machine. The object of this investigation is to simplify and considerably reduce the height of tea drying chambers through which the leaf being dried traverses.

As the factors involved in drying tea are said to influence the finished product it is necessary to establish this aspect of tea manufacture before embarking upon the intended purpose of this design, which is to combine the structural and mechanical components into a fermenting-cum-drying machine with each section catering for the special needs of the process.

ASSAM ADVISORY BRANCH—ASSAM VALLEY

P. M. GLOVER—Senior Advisory Officer, Assam.

P. C. SHARMA—Assistant Advisory Officer.

STAFF.

The Senior Advisory Officer, Assam was on U. K. leave 19th May—24th October, during this period Mr. E. D. Heath, Advisory Officer, Cachar acted for him.

Dr. P. C. Sharma returned from Cachar on 7th January, where he had been acting for the Advisory Officer, Cachar during his absence on U. K. leave. He was on leave in India 7th March—21st April.

Mr. Mitra, Assistant Advisory Officer left to take up his duties in West Bengal on 8th April 1957. Mr. Grice was also posted to West Bengal on 19th October.

Mr. Gray left for the North Bank on 19th December 1957 to open a new Advisory Sub Station in the Tezpur Circle. This station is temporarily sited at Thakurbari T. E., Borjuli P. O. Assam.

TOURING.

The following garden visits were made by the Senior Advisory Officer, Advisory Officers and Assistant Advisory Officer in the Assam Valley:

Assam Valley: South Bank.

Jorhat Circle	...	21 gardens.
Golaghat Circle	...	10 ,,
Moran Circle	...	12 ,,
Panitola Circle	...	12 ,,
Sonari Circle	...	2 ,,
Tingri Circle	...	15 ,,
Nazira Circle	...	14 ,,
Nowgong Circle	...	5 ,,
Doom Dooma Circle	...	17 ,,
Dibrugarh Circle	...	6 ,,
Nahorkatiya Circle	...	4 ,,

Assam Valley: North Bank.

Borsola Circle	...	10 gardens.
Tezpur Circle	...	15 ,,
North Lakhimpur Circle	...	7 ,,
Bishnauth Circle	...	10 ,,
Cachar District	...	2 gardens.

Several visits were of more than one day's duration, and a number of gardens were visited on more than one occasion. Included in the above are 23 visits to gardens not members of the Indian Tea Association.

The Senior Advisory Officer visited Cachar 28th November—2nd December. While acting in Assam Mr. Heath made frequent visits to Cachar, which was also visited by Mr. Gray and Mr. Swan, and by the Assistant Advisory Officer, Assam.

While on leave in the U.K. the Senior Advisory Officer, Assam visited the following:

Messrs. Four Oaks
Messrs. Cooper Peglers
Messrs. Micron Sprayers
Messrs. Fisons Research Station, Chesterfield Park
Messrs. Shell Chemical Research Station, Woodstock
Messrs. Plant Protection Research Station, Fernhurst
Messrs. Geigy's Research Station, Basle, Switzerland
Messrs. Auster Aircraft Ltd.
Colonial Insecticide Development, Porton

MEETINGS.

The Acting Senior Advisory Officer attended the Moran Circle A.B.I.T.A. meeting on 1st August.

The Senior Advisory Officer attended the Annual General Meeting A.B.I.T.A. held at Jorhat on 16th November.

LECTURES AND DEMONSTRATIONS.

The following lectures were given by the Senior Advisory Officer.

Shade New Pesticides and their uses	Borsola Club 10th January.

The Senior Advisory Officer summarised "Environmental and Climatic Factors in relation to the Assam Valley" at the Annual General Conference held at Tocklai 12th-14th November.

Tocklai took part for the first time in the Annual Exhibition held at the Jorhat Club during Race Week 4th-9th February. A Tocklai Stall was organised by the Advisory Branch and proved very popular with visitors to the Exhibition. It is hoped to make this an annual feature of the Exhibition.

The following demonstrations were attended:

Overhead Irrigation with Wright Rain medium pressure equipment Jorhat Club 15th February.

"Vibro" Hoe at Cinnamara T.E. 22nd February.

Hesford Winch for uprooting Tea: Cinnamara T.E.: 19th July.

Ferguson Blade Terracer at Cinnamara T.E. on 1st April 1957.

The Sirocco Drum Withering System at Kellyden T.E: 3rd December.

COURSE.

Three Lecture Courses each of four days' were conducted by the Advisory Branch.

1st Lecture Course	...	18th-21st February.
2nd Lecture Course	...	25th-28th February.
3rd Lecture Course	...	4th- 7th March.

Lectures were given by the Senior Advisory Officer, Assam and Senior Advisory Officer, West Bengal, the Advisory Officer Cachar, The Tocklai Tea Taster, and the Acting Resident Engineer.

On each Course mornings were devoted to Lectures and afternoons to outdoor demonstrations.

A total of 81 Planters attended of which 8 were Borbhetta Trainees and 6 were non members of the Indian Tea Association, Calcutta.

The Acting Senior Advisory Officer gave a Lecture on each Vegetative Propagation Course on "Commercial application of Vegetative Propagation".

ADVISORY CORRESPONDENCE.

612 letters and memoranda of an advisory nature were written during the year of which 58 were to gardens non members Indian Tea Association.

PUBLICATIONS.

The following Tea Encyclopaedia Serials were published during the year:

"Infilling and Treatment of Infills" T. E. Serial No. 43/2 revised in co-operation with the Senior Agriculturist.

"A Note on Spraying technique against Blister Blight" Appendix to T. E. Serial No. 62/1 revised.

"Branch Die Back and Nectria" T. E. Serial No. 65/2 revised in co-operation with the Mycologist.

"Recipes for Pesticides which can be prepared Home made on the garden" T. E. Serial No. 33/3 revised.

"Hail Damage on Tea Estates" T. E. Serial No. 36/2 revised in co-operation with the Senior Agriculturist and Mycologist.

"The Prevention and Cure of Red Rust" T. E. Serial No. 61/1 revised in co-operation with the Mycologist.

"Crotalaria anagyroides" T. E. Serial No. 40/2 revised in co-operation with the Senior Agriculturist.

"Green Cropping Programme for Shading Tea Seed Nurseries" T. E. Serial No. 59/2 revised.

"Vegetative Propagation" A new T. E. Serial No. 117 was written.

"Medium Pruning" T. E. Serial No. 53/2 revised in co-operation with the Senior Agriculturist.

The following articles were published in "Two and a Bud":

(*a*) "Practical Aspects of Spacing and Arrangement of Tea Plants in Commercial Tea Estates".

(*b*) "The Use of Pressure Regulating Devices with Air Pressure Retaining Pneumatic Knapsack Sprayers".

TECHNICAL REPORTS.

Subsoiling:

The Ebhordt. Sub-soiler towed by a Fordson Tractor did a better standard of work than that done by the Ferguson subsoiling attachment: the former cut deeper and caused much less soil disruption. To obtain an equivalent depth with the Ferguson subsoiling attachment two runs must be made down the same line.

The ground should be as level as possible before subsoiling is undertaken. Cavities, left by uprooting, must lead to an uneven depth of cutting and if they also coincide with a big underground obstruction the tractor can become "bogged" down. The area should be ploughed and rotavated and then subsoiled. A second rotavating, if deemed necessary, can take place after subsoiling.

A man should walk behind the subsoiler and should mark obstructions (such as roots) which it cannot remove, with a flag. Such obstructions must be removed later by digging.

Subsoiling is slow, with a single cut in one direction only, each cut being 4′ apart, the tractor must travel some 3600 yards to cover an acre; allowing for delays due to obstructions, this will take not less than $1\frac{1}{4}$ hours. With two direction subsoiling which is preferable, not less than $2\frac{1}{2}$ hours are required per acre. If subsoiling in one direction only, is possible, then this should be done at right angles to the line of the future hedges where Hedge Planting is the practice.

To reduce tyre slip when subsoiling spade wheels should be fitted to the tractor.

Ransome Vibro Hoe :

A preliminary trial with the Ransome "Vibro" Hoe suggested that suitably modified it could have considerable potential value for use in the cultivation of young tea.

The existing clutch system however is such that its life would be extremely limited under tea garden conditions, and in its present form it is not suitable for garden work.

This matter has been taken up with the manufacturers.

Flush Worm (Laspeyresia leucostoma) :

Incidence of Flush Worm has been considerable this year, mainly confined to the area N. E. of Sibsagar, and most severe in Moran, Dibrugarh and Panitola Circles.

Red Spider (Oligonychus bioculatus) :

Incidence was rather severe during April and May in the Golaghat and Tezpur Circles consequent upon a long period of hot dry weather.

Red Rust (Cephaleuros parasiticus) :

Fruiting over a wide area in the Assam Valley was much later than usual this year and times for spraying rounds were modified accordingly, to first round 1st week and 2nd round last week in May.

Rim Blight :

Following upon Green fly (Jassid) attack Rim Blight was very severe in some gardens in Tezpur Circle. The attack was most marked in medium pruned tea.

Leaf Damage similar to that produced by Tea Mosquito :

This was first observed at Tyroon and later, on almost every garden visited to a greater or less extent. It appears that an insect similar to *Helopeltis theivora* must be responsible.

Four Oaks Tractor mounted sprayer :

The Senior Advisory Officer visited Messrs. Four Oaks while on leave in the U.K. on several occasions. As result of discussions and trials a new Mark II Four Oaks Tractor

mounted sprayer has been produced, whose major improvements are:

(*i*) A completely new pump and drive thereto. The pump is centrifugal and gives ample pressure and to spare. It will not be subject to wear as was the previous pump and should give prolonged service without trouble.

(*ii*) Two filters have now been fitted instead of one, they have been so sited as to be easily accessible for cleaning; either one or both can be used at will.

(*iii*) The hose length has been considerably increased giving much greater potential coverage. The actual weight of the hose will be much less than before as light plastic small diameter hose has been substituted for large diameter rubber hose.

EXPERIMENTS.

N. P. K. Manuring Experiments:

Three levels of nitrogen N_0 N_{40} and N_{80} each with three levels of phosphate and potash 0 - 40 and 80. At N_{80} an additional level of P and K, 20 is added. There are 34 treatments in two repeats.

Panitola T. E.: Mature Tea.— In the third year of this experiment the effect of nitrogen was highly significant both 40 lbs. and 80 lbs. being significant over no nitrogen, 80 lbs. N was also significantly better than 40 lbs. N ($P = 0{\cdot}001$). NP, NK and NPK interactions were not significant; (at P 0·05), the P.K. interaction however is significant. At K_0 and K_{80} phosphate 40 lbs. increases yield while at K_{40} a similar amount of phosphate produced a marked reduction. At the level of 80 lbs. N per acre there are four levels of P and K; these are 0-20-40-80. At this level of nitrogen the P, K and PK interactions were not significant.

Panitola T. E.: Young Tea.— In the third year of treatment effects were calculated both on yield of green leaf plucked and on weight of prunings. The absolute uniformity of the results obtained by each of these methods was most marked.

The effect of nitrogen was not significant ; potash however produced a highly significant effect (P. 0·001). Both K_{40} and K_{80} produced yields significant over K_0, there was however no difference between K_{40} and K_{80}. In the absence of Potash, nitrogen at 80 lbs. gave yields lower than from nitrogen at 40 lbs. or no nitrogen. With 40 lbs. Potash, there was no difference in yield with any of the three levels of nitrogen. At K_{80} nitrogen at 80 lbs. gave yields greater than from either N_{40} or no nitrogen. At 80 lbs. nitrogen there are four levels of Potash 0-20-40-80. The effect of potash was highly significant (P=0.01). K_{20} K_{40} and K_{80} were significant over K_0, and K_{80} was significant over K_{20} and K_{40}.

Borjuli T. E.: Mature Tea.—This experiment while complementary is of somewhat different design, there are two levels of nitrogen, 40 and 80. At each there are three levels of each phosphate and potash, 0,20 and 40. There are 19 treatments in three repeats. In the second year of treatment as in the first the overall effect of fertiliser against no fertiliser was highly significant (P. 0·001). In 1957 the effect of nitrogen became highly significant, the effect of 80 lbs. per acre being significant over 40 lbs. per acre. Phosphate and potash had no significant effect in 1957.

In each of the three following experiments there are three levels of nitrogen 80-120-160 and at each there are three levels of phosphate and of potash, 0-20 and 40. There are 27 treatments in three repeats.

Murmuria T. E.: Young Tea.- Replanted March April 1954. Preliminary yields were taken in 1956, and manures were applied for the first time in 1957. There was no significant difference between any treatment.

Margherita T. E.: Young Tea.— Preliminary yields were taken during the current year, and manures will be applied for the first time in 1958.

Khoomtaie T. E.: Young Tea.— Preliminary yields were recorded during 1957, fertilisers will be applied to the plots in 1958.

Manuring of Bheel Soils :

At Sephinjuribheel T. E. in Cachar, this experiment is being conducted by the Scientific Officer, Jokai Assam Co., with our co-operation.

The yield from plots manured with P_2K_3 was significantly better than from plots manured with P_1K_1, and the yield from P_1K_1 better than from P_0K_0 ($P=0{\cdot}05$).

The interaction between nitrogen and levels of PK was also significant. In the presence of nitrogen, the yields from P_2K_3 and P_1K_1 were both greater than from P_0K_0 but the difference between them was not significant (P 0·05). Nitrogen significantly increased yield in the absence of P and K had no effect at P_1K_1 and depressed yield at P_2K_3.

In so far as mortality is concerned, deaths were significantly greater in plots receiving no P and K than in those manured with P and K (P 0·05). Differences between individual treatments were not significant.

Inorganic versus Organic nitrogen :

Halem T. E.— This experiment is now in its 26th year. The treatments are as follows :

No manure
Cattle manure at 16,000 lbs. per acre.
Sulphate of ammonia at 40 lbs. N. per acre with the addition of 20 lbs. each phosphate and potash.

Once again in 1957 yields from both organic and inorganic fertilisers were significantly greater than from the check plots ($P=0{\cdot}001$). The difference in yield between organic and inorganic fertiliser was not significant.

Jamirah T. E.- This experiment is now in its tenth year. The treatments are as follows:

No manure
80 lbs. nitrogen as sulphate of ammonia.
80 lbs. nitrogen as oilcake.

As in 1956 both organic and inorganic fertilisers gave yields significant over the unmanured plots (P=0·001). The soil is light and sandy and on this soil there is no difference in yield between organic and inorganic manured plots.

Manuring of medium pruned tea :

A small field trial was laid out in co-operation with the Scientific Officer Jorehaut Tea Company at Cinnamara T. E. on the manuring of medium pruned old tea. There are three treatments with five repeats, as follows:

80 lbs. N per acre as NPK Young Tea 1-2-2 mixture.
80 lbs. N per acre as NPK seed bari mixture.
80 lbs. N per acre as Sulphate of ammonia.

In the year of medium prune there was no significant difference between any of the treatments. It is possible however that with old tea any value that phosphate and potash may have will show up in the year following medium prune. This will be watched in 1958 when all plots will be manured with 80 lbs. nitrogen as sulphate of ammonia.

Shade, Nitrogen and Plucking :

This experiment on the interaction between Shade, Nitrogen and Plucking at Hunwal T. E. is now in its tenth year.

Treatments were shade and no shade. Two levels of tipping 6″ and 9″ and two levels of nitrogen 40 and 120, with at each level 40 lbs. each phosphate and potash.

In 1956-57 cold weather the area in which these plots are situated was medium pruned, and with it the experimental area. During this season all plots were plucked and manured alike; with the object of investigating what residual effect treatments previously applied would have following medium prune.

There was no significant difference in yield between plots previously manured with either the higher or lower level of nitrogen, nor between those harder or more lightly plucked.

A gain from shade of +0·98 mds. was significant at the 1% level.

Eelworm :

A new field trial was laid out at Behubor T. E. to examine the efficiency of Soil Steriliser YX 564/57 supplied by Messrs. Plant Protection Imperial Chemical Industries against eelworm.

Soil samples have been collected for estimation of initial eelworm population. Treatments are

2 pints YX 564/57 in 20 gallons water per 100 sq. ft. watered in with 30 gallons water per 100 sq. ft.
Control 50 gallons water per 100 sq. ft.

There are ten repeats in randomised block. Treatments were applied on 9th and 10th December. Seed is to be sown after an interval of three weeks.

Disease of Tea Flowers attributed to Botrytis sp. (Sclerotiniaceae) :

Six field trials have been laid out in commercial Tea Seed Baries using Fernide (T. M. T. D.) as follows:

(*a*) *Dhelakhat T. E.*:

High volume applied by means of a Universal major orchard sprayer towed by a Fordson Tractor. There are three treatments with eight repeats as follows:

Fernide + Teepol
Water
Check.

Four rounds have been applied at approximately two weeks intervals. As flowering appears likely to be prolonged, a fifth round will be applied in early January as necessary.

(*b*) *Khorijan Tea Seed Bari*:

(*c*) *Tingamira Tea Seed Bari*:

Low volume applied by means of a Fontan Aerosol spray unit. There are two treatments with ten repeats, as follows:

Fernide plus Teepol
Check

Four rounds were applied at approximately two weeks interval, the first round being in the first week of November.

As flowering appears likely to be prolonged, at Tingamira a fifth round will be applied early January, if necessary.

(*d*) *Sealkotee T. E.*:

(*e*) *Deohall T. E.*:

(*f*) *Thowra T. E.*:

Low volume applied by means of the Fontan Aerosol spray unit. There are two treatments with ten repeats, as follows:

Fernide plus Teepol,
Water plus Teepol.

Four rounds were applied at roughly two weeks interval, the first being the first week in November. As flowering at Deohall T. E. appears to be prolonged a fifth round will be applied in early January, if necessary.

Table 1. summarises treatments, dates, and gallonage per acre applied for all the above experiments.

Estimation of effect in each case will be determined by seed collection in 1958.

Site	Tree size, spacing & No. per acre.	Date of Application	Machine & Jet size	Gall Spray fluid & lb. 'Fernide' per acre.	Gall. water per acre.
Deohall	Large, 15-20′ high 12′ square 302	6th/7th November	'Fontan' No. 4	30 gall. 5 lb.	30 gall = 0.0013″ rain
		28th/29th November	'Fontan' No. 4	30 gall. 5 lb.	30 gall = 0.0013″ ,,
		6th December	'Fontan' No 2.5	30 gall. 5 lb	30 gall = 0 0013″ ,,
		20th December	'Fontan' No. 2.5	30 gall. 5 lb.	30 gall = 0.0013″ rain
Khorijan	Small/Medium, 8-10′ high 12′ triangular 349	7th November	'Fontan' No. 4	21 gall. 3.5 lb.	...
		20th November	'Fontan' No. 4	18 gall. 3 0 lb.	...
		3rd December	'Fontan' No. 3	22.5 gall. 3.8 lb.	...
		18th December	'Fontan' No. 3	23 gall. 3.8 lb.	...
Dhelakhat	Large, 15-20′ high 18′ square 134	8th November	'Universal Major' No. 3. 400 lb.	100 gall. 4.5 lb.	100 gall = 0.0045″ rain
		20th November	'Universal Major' No. 3. 400 lb.	100 gall. 4.5 lb.	100 gall = 0.0045″ ,,
		3rd December	'Universal Major' No. 3. 400 lb.	75 gall. 4.5 lb.	80 gall = 0.0036″ rain
		19th December	'Universal Major' No. 3. 400 lb.	90 gall. 4.5 lb.	90 gall = 0.004″ rain

Site	Tree size, spacing & No. per acre.	Date of Application	Machine & Jet size	Gall Spray fluid & lb. 'Fernide' per acre	Gall. water per acre.
Sealkottee	Small 6-8′ high 18′ square 134	8th November	'Fontan' No. 4	12 gall. 2 lb.	12 gall. = 0.00054″ rain
		22nd November	'Holder Harriden' Knapsack Fan-Jet C. 60	15.5 gall. 2.3 lb.	12 gall. = 0.00054″ ,, (Motoblo/Fontan).
		5th December	'Fontan' No. 3	12 gall. 2 lb.	12 gall = 0.00054″ rain
		17th December	'Fontan' No. 3	12 gall. 2 lb.	12 gall = 0.00054″ ,,
Tingamira	Medium/Large, 12-15′ high 18′ triangular 155	10th November	'Fontan' No. 4	19.5 gall. 3.3 lb.	...
		21st November	'Motoblo'/'Fontan' No. 4	22 5 gall. 3.8 lb.	...
		4th December	'Fontan' No. 3	21 gall 3.5 lb.	...
		18th December	'Fontan' No. 3	21 gall. 3.5 lb.	...
Thowra	Medium. 10-12′ high 12″ square 302	11th November	'Fontan' No. 4	27 gall. 4.5 lb.	27 gall = 0.0012″ rain
		24th November	'Holder Harriden' Knapsack Fan-Jet C. 60	37.5 gall. 4.7 lb.	42 gall = 0.0019″ ,,
		7th December	'Fontan' No. 3	28.5 gall 4.8 lb.	24 gall = 0.0011″ rain
		21st December	'Fontan' No. 3	27 gall. 4.5 lb.	25.5 gall = 0.0012″ ,,

ASSAM ADVISORY BRANCH—NORTH BANK

D. J. GRAY—Advisory Officer, North Bank

STAFF

The North Bank Advisory Branch was opened on December 20th in temporary accommodation on Dhulapadung Tea Estate. Mr. Gray was posted to the area to take charge.

TOURING

Prior to the establishment of the Branch, advisory visits were made to five gardens in the Bishnauth Circle and one in the Tezpur Circle.

MEETING

The Advisory Officer attended the Tocklai Annual Conference 12—14th November, 1957.

PUBLICATION

"*Gliricidia sepium* as a Shade Tree" in Two and a Bud Vol. IV. No. 3 September, 1957.

EXPERIMENTS

A replicate of the seed trial being carried out in Cachar, Dooars and Upper Assam was initiated on Monabarie T. E. The seeds under trial, provided by the Botanical Department, Tocklai together with Khorijan and Gaurisankar for comparison were sown in beds under green crop shade on November 22nd. Three beds of each kind of seed were put out to give three blocks, each containing one bed of each kind of seed, arranged randomly.

The following experiments are already being conducted in the North Bank area: (*a*) a Nitrogenous manure experiment on Halem T. E. and (*b*) an N.P.K. experiment on Borjuli T. E.

STATION REPORT

By the end of the year preliminary consideration had been given to the permanent arrangements for the branch.

ASSAM ADVISORY BRANCH—CACHAR

E. D. HEATH—Senior Advisory Officer.

STAFF

During 1957 the Advisory Officer acted for Mr. P. M. Glover during the latters absence on U. K. leave. Monthly visits to Tocklai were paid in this connection between May and September inclusive. The Advisory Officer was promoted to the Senior Grade during the year.

TOURING

In Cachar district 88 garden visits were made, including visits to 8 non-members. The Advisory Officer also visited 27 gardens in the Assam Valley whilst acting for Mr. Glover. These are included with those listed in the Assam Valley report.

MEETINGS

The Senior Advisory Officer attended the Annual General Meeting of the Surma Valley Branch Indian Tea Association in February, and the Tocklai Annual Conference in November. He also attended the United Planters' Association of Southern India Annual Conference at Conoor in March.

LECTURES

During the Annual Lecture Courses at Tocklai the Senior Advisory Officer gave lectures on "Tea Nurseries", "Manuring", "Shade", "Leaf Transport and Withering".

During the Annual Vegetative Propagation Courses in May lectures were given on "The Commercial Application of Vegetative Propagation".

DEMONSTRATIONS ETC.

Tea Tasting sessions were held during the year at the Monacherra Club, Longai Valley Club and Boro-Jalinga Club, the first two being organised by Mr. Trinick and the last by Mr. Heath.

A demonstration of aerosol spraying machinery and technique was given by Mr. Heath at the Retreat Club, Silchar in June.

COURSES

The Advisory Officer attended and participated in the General Lecture Courses held at Tocklai between 10th February and 7th March, 1958.

ADVISORY CORRESPONDENCE

194 letters were written to gardens dealing with advisory matters and 367 administrative letters were written.

PUBLICATIONS

"Cachar Quarterly", Volume II Nos. 1-4 inclusive, were published during the year.

EXPERIMENTS

Garden Experiments

(In conjunction with S. K. Dutta, Agriculture Branch)

Level of Nitrogen Manuring :

Silcoorie Tea Estate (1956).— This experiment compares different rates of N applied as Sulphate of Ammonia at different times. In 1956 high rates of N tended to reduce yields, and in view of these results, the treatments were amended in 1957 to the following.

A. 80 lb. N (S. of A.) applied in March.
B. 80 lb. N (S. of A.) applied in March plus 40 lb. N (S. of A.) applied in August.

Table 1: *Yields in maunds made tea acre.*

Treatments.	Yield in	
	19·56	1957
A	19·00	14·84
B	15·96	13·93

Although the application of 120 lb. N (treatment B) has reduced the yield compared to 80 lb. N, the reduction was much less than in 1956 with 160 lb. N, and as anticipated was not significant. There is thus still no apparent need to increase the level of nitrogen manuring above 80 lb. N per acre to dark-leafed tea under heavy shade.

N. P. K. Experiments :

In these experiments combinations of N. P. K. are compared on different types of Cachar Soils. Some of the results are reported below.

Roopacherra Tea Estate (1955).— This experiment consists of two parts. In the first part there are three levels each of nitrogen, phosphate and potash. The levels are 0 lb., 40 lbs., and 80 lbs. per acre and the total number of treatment combinations is 27. In the second part there are four levels of each of phosphate and potash—0 lb., 20 lbs., 40 lbs. and 80 lbs. per acre in conjunction with 80 lbs. of nitrogen only. The analyses of 1957 yield figures have not shown any significant differences between the treatments either in the first or the second part. The direct effect of N, P and K were not significant nor the effects of different combinations of N, P and K. The summarised results of the overall effects of N, P and K are given in table 2.

Table 2: Yield in mds. made tea per acre.

Dose / Manure	0 lb.	40 lbs.	80 lbs.
N	12·79	12·83	13·53
P	12·90	13·52	12·74
K	12·89	13·01	13·26

Bhubandhar Tea Estate (1955).— This compares 1 level of N in combination with two levels of P and K on bheel soils.

No significant differences were recorded between treatments during 1957, although more positive trends were observed than in 1956, and for this reason it is considered desirable to continue the experiment. 1957 results are shown in table 3.

Table 3: Yields in Maunds made tea/ acre.

Year	NPK 000	NPK 100	NPK 001	NPK 011	NPK 012	NPK 022	NPK 122
1956	7·49	7·95	8·45	8·31	8·04	8·47	8·31
1957	9·14	8·39	8·81	10·16	9·24	9·50	9·33

Pathini Tea Estate (1956): Chandkhira Tea Estate (1956): Sephinjuri bheel Tea Estate (1956).— N. P. K. experiments are also being conducted on these tea estates. The first two were started in 1956 and have not so far produced any interesting results. The last is conducted in conjunction with the Scientific Officer Jokai (Assam) Tea Co., and is reported in the Assam Valley report. Significant results from P. & K. have been recorded in this experiment.

Pruning Cycle Experiments:

In these experiments different pruning and skiffing combinations are compared. There are in all five experiments of which three are reported below.

Burnie Braes Tea Estate (1955).— This experiment was started in 1955 with the following treatments.

1. Annual Prune ($\frac{1}{2}''$ up).
2. Alternate prune and light skiff.
3. Alternate prune and deep skiff.
4. Prune 1″ up—Light skiff—Deep skiff.

The following table gives the yield in maunds of made tea

per acre for the years 1955, 1956 and 1957. The 1955 yield figures, however, are not adjusted.

Table 4: Yields in Maunds made tea/acre.

Treatment.	1955		1956		1957		
	How Pruned	Yield	How Pruned	Yield	How Pruned	Yield	Total
1.	Prune at 24"	15.17	Pruned ½" up	18.51	Pruned ½" up	15.92	49.60
2.	Prune at 24"	16.03	Light skiffed	23.98	Pruned 1" up	17.35	57.36
3.	Prune at 24"	16.66	Deep skiffed	23.07	Pruned 1" up	16.90	56.63
4.	Prune at 24"	16.30	Light skiffed	23.85	Deep skiffed	21.09	61.24
S. D. (P=0·05)		...		1.43		1.21	

In 1956 treatments 2, 3 and 4 were skiffed and all gave significantly higher yields than the annual prune (treatment 1). There was no significant difference between treatments 2, 3 and 4. In 1957, treatment 4 was deep skiffed and gave a significantly higher yield than all other treatments. Treatment 2, pruned 1" up in that year also gave a significantly higher yield than the annual prune. There was no significant difference between treatment 2 and 3 and also between 3 and 1. It will be appreciated that a valid assessment of over-all effects can only be made by comparing total yields for the period of the experiment in the 6th year when all cycles revert to the same place.

Aenakhall Tea Estate (1955).—This experiment was initiated in 1955. All the treatments were pruned at the same height and preliminary yield records were taken from August 1955 to end of the season and 1956 and 1957 yield figures have been

adjusted against these. The adjusted summarised results of the experiment are given below.

Table 5. Yield in Maunds made tea/acre.

Treatments	1955 (Preliminary year 2-8-55 to 15-12-55)		1956		1957	
	How Pruned	Yield	How Pruned	Yield	How Pruned	Yield
1. (Annual Prune) ...	Pruned	10.60	Pruned ½" up	18.20	Pruned ½" up	17.08
2. (Alternate prune and light skiff) ...	Pruned	12.68	Light skiffed	25.91	Pruned 1" up	17.27
3. (Alternate prune and deep skiff) ...	Pruned	12.76	Deep skiffed	25.81	Pruned 1" up	17.97
4. (Prune ½"—Light skiff Prune 1") ...	Pruned	10.84	Light skiffed	22.84	Pruned 1" up	16.81
S. D. (P=0·05) ...		...		5.16		Not Significant

The above table shows that in 1956 there were significant differences between the treatments. All the skiffed treatments *i.e.* Treatment Nos. 2, 3 and 4 gave higher yield than Treatment No. 1 which was pruned but only in case of Treatments 2 & 3 the increase was significant. There was no difference between Treatments 2, 3 and 4 and between Treatments 1 and 4. In 1957 all the four treatments were pruned and no significant results were obtained. A final assessment must of course be based on a comparison of total treatment yields after completion of a sufficient number of treatment cycles.

Larsingah Tea Estate (1955).—The treatments being the same as those of the Aenakhall T. E. experiment. Table 6 gives the

yield in maunds of made tea per acre for the years 1955, 1956 and 1957. The 1955 yield figures, however, are not adjusted.

Table 6: Yield in maunds made tea/acre.

Treatment	1955		1956		1957		Total
	How Pruned	Yield	How Pruned	Yield	How Pruned	Yield	
1.	Prune at 32½"	14.11	½" up	15.13	½" up	11.10	40.34
2.	Prune at 32½"	14.19	Light skiff	19.06	Prune 1" up	8.35	41.60
3.	Prune at 32½"	13.53	Deep Skiff	19.60	Prune 1" up	8.96	42.09
4.	Prune at 32½"	13.90	Light skiff	19.71	Prune 1" up	9.38	42.99
S. D. P=0.05		...		3.45		1.80	

Significant differences in yield have been obtained in 1956 and 1957. In 1956 all the three skiffed treatments gave significantly higher yield than the annual prune. There was, however, no significant difference between the skiffed treatments. In 1957, the result was just the reverse, and the annual prune gave significantly higher yield than treatments (2) and (3) and just missed being significantly different in case of treatment (4). As in the other experiments, final assessments cannot be made at this stage.

W. Jalinga Tea Estate (1955) and Borokai Tea Estate (1955).— These are exactly similar experiments to those reported above.

District Clonal Trials:

In these trials standard clones from Tocklai are compared under different conditions to establish the interaction between the clones and their environment. During the year clonal mate-

rial was received from Tocklai to make up deficiencies due to nursery mortalities. The " Teela " repeat of this trial was planted up in April/May 1957 under good green-crop cover of *Crotalaria anagyroides*. The " Clay Flat " repeat will be planted up in Spring 1958. Owing to severe drought conditions at the end of 1957 (no rain fell after mid October) casualties on the " teela " have been quite substantial. However, as the mortality rate from drought has varied considerably between clones these figures alone will provide valuable information as to their suitability for Cachar District.

District Trial of Alister's Dhonjan Seed—Silcoorie Tea Estate :

Early in 1957 it was reported from various sources that the seed of Alisters Dhonjan (Commercial bari of stock 203 from Tocklai) was lacking in uniformity in respect of seedling size.

A 4 lb. sample of Alisters Dhonjan seed received here for trial, was put out in a teela nursery with 4 lb. of Dangri seed as a comparison in December 1956. The only difference in treatments in this comparative trial was that Dangri was pregerminated whereas Alisters Dhonjan was not. Consequently, seed of Dangri came through earlier, and for most of the season appeared to be ahead of Alisters Dhonjan. At no time however was there any visible difference in the variation of seedling size between the two jats.

By visual observation in January 1958, there was little to choose between either jat, except that any size difference at all would be considered in favour of the Dangri. On 28-1-58, measurements were taken with a Rabens gauge of the collar diameters of both jats. The sampling was at random, the sampling population being 200 plants of each jat. The results are shown in graphic form in fig. 1. (*P. 216*)

Actual figures showed the average collar diameters to be as follows :—

Dangri	7.84 mm.
Alisters Dhonjan	6.37 mm.
Difference	1.47 mm.

It is felt that as the difference appeared to have been maintained right from the start it may be due entirely to the pregermination of the Dangri seed.

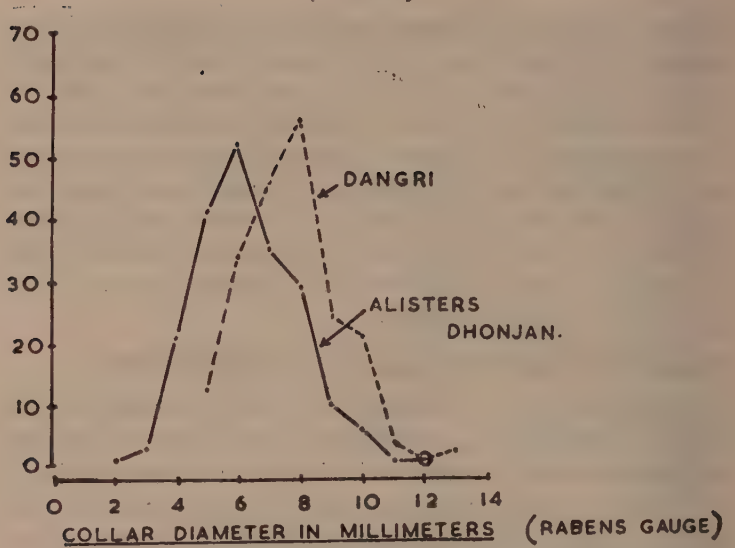


Fig. 1. Size distribution of Random sample of 200 plants each of Dangri and Alister's Dhonjan in Doorgakhoona 1957 Teela Nursery.

Silcoorie T. E.
(Observations taken on 28.1.58.)

The graph appears to confirm the observation that there is no greater variation in seedling size of Alisters Dhonjan than of Dangri, the latter being accepted as a uniform jat. Distribution curves are identical for both jats.

Phosphate Deficiency of Sun Grass—Silcoorie Tea Estate :

In April 1956, certain areas of Sungrass at the Dhurrumkhal Division of Silcoorie T. E. were observed to be dying back. The areas concerned were very old tea land, the tea having been uprooted some 6-7 years previously. Symptoms were marked purplish-brown discolouration of the leaf blade, beginning at the apex and spreading downwards. In extreme cases, the leaf blade became discoloured throughout its entire length, followed by marginal necrosis and eventual death of the aerial portion of the plant. Regrowth occurred after some time, and discolouration and necrosis followed again. As these symptoms have been observed to be widespread in Cachar, and as there is, in many tea estates, a deficiency of Sungrass for the annual maintenance of labour houses etc., a small field trial was planned to deter-

mine whether or not prophylaxis would be an economic proposition.

Only three treatments were included in the trial and these were as follows:

1. Control (no Manure).
2. Superphosphate @ 100 lb. per acre.
3. NPK mixture @ 800 lb. per acre.

The Superphosphate contained 18% P_2O_5 thus supplying 18 lb. P_2O_5 per acre. The NPK mixture contained 5% N, 10% P and 10% K, thus supplying 40 lb. N_2, 80 lb. P_2O_5 and 80 lb. K_2O per acre.

Treatments were applied in May 1956, but by this time, marginal necrosis had set in almost throughout the area and no direct effect was observed in the year of application. One year later however, (in May 1957) the effect was most marked visually. The control areas were showing the symptoms of discolouration and necrosis to a marked degree, whereas treated areas appeared a fresh, bright green throughout, with no visible discolouration.

From each plot in each treatment five random frames, measuring 1 sq. yd. each, were cut at ground level and the sun-grass weighed. Table 7 gives the sample weights taken on 7-5-57.

Table 7: Fresh Weight of Sungrass/sq. yd.

Treatment	1	2	3
Frame 1 ...	2 lb. 8 oz.	2 lb. 12 oz.	3 lb. 4 oz.
Frame 2 ...	1 „ 14 „	2 „ 4 „	2 „ 12 „
Frame 3 ...	12 „	2 „ 2 „	3 „ 8 „
Frame 4 ...	1 „ 2 „	2 „ 14 „	2 „ 2 „
Fram 5 ...	1 „ 2 „	2 „ 2 „	2 „ 6 „
TOTAL ...	7 lb. 6 oz.	12 lb. 2 oz.	14 lb. 0 „
AVERAGE ...	1 lb. 7½ „	2 lb. 7 oz.	2 lb. 13 „

These figures indicate that treatment 2 (18 lb./acre P_2O_5) has increased the fresh weight of sungrass by 66%, and treatment 3 (40 lb. N_2, 80 lb. P_2O_5, 80 lb. K_2) by 91.5% over the control. Further observations and measurements will be taken during the year, but meanwhile the following conclusions might be drawn.

1. Both treatment 2 and treatment 3 have eliminated the symptoms of discolouration and marginal necrosis in sungrass. The only factor common to both treatments is phosphate, and it is reasonable to assume therefore that the symptoms were those of phosphate deficiency which has been cured by as little as 18 lb. per acre of P_2O_5.

2. The further increase gained from the applications of NPK mixture, (treatment 3) is most likely to have resulted from the 40 lb. Nitrogen in the mixture. In certain circumstances there is no doubt a level of nitrogenous manuring which would be an economic means of increasing the yield of sungrass.

3. If nitrogenous manures were to be added to sungrass areas deficient in phosphate then probably more than 18 lb. P_2O_5 per acre would be required to compensate for the increased crop to be expected from the nitrogen. (This inference is not drawn from this experiment, but from the results of similar, though more detailed, experiments elsewhere).

4. Value of Sungrass locally is about Rs. 1.50 nP per maund, and the average yield, unmanured, is 100 mds./acre. Cost of 100 lb. superphosphate is about Rs. 16.00 applied. Cost of cutting an extra 66 mds. of sungrass is about Rs. 23.00. Thus for an all-in cost of less than Rs. 40.00 additional sungrass worth Rs. 100.00 has been obtained.

Trials with Shell Copper and Shell Tenac—Silcoorie Tea Estate :

A randomised block trial using Shell products against Red Rust was carried out in 1957. The treatments, each repeated 6 times for two spraying rounds, were :

I. Shell Copper @ 1 lb. in 40 galls.
II. ,, ,, @ 1 lb. in 40 galls. plus ½ lb. Shell Tenac.
III. ,, ,, @ 10 oz. in 40 galls. plus 5 oz. Shell Tenac.
IV. Control.

Observations were taken subsequently at monthly intervals from June to August, but no significant results were obtained. The trial will be repeated during 1958.

Dranjuk Seed Trial—Aenakhal Tea Estate :

Seeds of Dranjuk, Gaurisankar and Khorijan were received from the Botany Dept. in November 1957 and planted out in a randomised block nursery at Aenakhal T. E. Plants will be lifted in Spring 1958 and put out in accordance with the plans agreed upon by the Selection Officer and Senior Agriculturist.

Branch Experimental Area

White Ant Control Trial—Silcoorie Tea Estate :

The treatments using Aldrin & Dieldrin formulations were applied here early in 1955, and observations are still being taken to determine the persistency and residual action of the insecticides. To date it is worth noting that in no plots at all other than untreated areas has any white ant reinfestation occurred. All treatments therefore may be regarded as 100% effective for at least 3 years.

Pruning of Young Tea—Advisory Branch Plot 2 :

Four kinds of tea were planted out from the Branch nurseries in April/May 1957, these being Betjan, Dangri, Gaurisankar and Clone Rt/6 (F). Five types of pruning treatment are being applied to each kind of tea, commencing with the cold weather of 1957/58.

Treatments are as follows:

Treatment 1.—Tocklai standard pruning and plucking.

Treatment 2.—Year 1 Skiff @ 42″.
,, 2 Skiff @ 36″ and pluck @ 40″.
,, 3 Skiff @ 36″ and pluck @ 40″
,, 4 Prune @ 30″ and pluck @ 40″.
,, 5 Skiff @ 36″ and pluck @ 40″.

Treatment 3.—Year 1 Unpruned, unplucked.
,, 2 Cut across @ 40″ in spring, no plucking.
,, 3 Centre 9-15 inches, pluck @ 40″.
,, 4 Skiff @ 40″.
,, 5 Cut across @ 18″ and centre, pluck @ 40″.

Treatment 4.—Year 1 Unpruned, unplucked.
,, 2 Prune @ 6″, December, tip @ 36″.
,, 3 Prune @ 11″, pluck 36″.
,, 4 Prune @ 16″, pluck 36″.
,, 5 Skiff @ 36″, pluck to Janam.

Treatment 5.—Tocklai standard prune, no centering after 1st year.

In this trial, Treatments 1 & 5 were carried out by the Senior Advisory Officer on December 30th, 1957. Treatment 2 will be carried out in April 1958. Treatments 3 and 4 require no action during the current season.

SILCOORIE STATION REPORT

Visitors :

Messrs. Das & Katani, Pathological Branch assistants, were resident at the branch during January studying the life cycle of the Flushworm (Enarmonia leucostoma). Mr. Ganguly carried out further studies on Flushworm at Silcoorie T. E. in February/March.

Mr. Chakrabarty, Meteorological Assistant from Tocklai, visited the Branch during January to assist with the installation of Meteorological equipment.

Mr. Gokhale, Senior Physical Chemist, toured several Cachar gardens during May in connection with flooding and silting of tea areas.

Mr. Trinick, Tea Taster, toured the district extensively in April/May, visiting 16 factories and tasting teas of 25 gardens.

Mr. Swan, Mr. Grice, Mr. Gray and Dr. Sharma paid advisory visits to Cachar gardens during the year, largely whilst Mr. Heath was engaged at Tocklai.

Dr. Das, Senior Entomologist, visited Silcoorie and Serispore T. E.s in connection with Flushworm investigations.

Representatives of Messrs. Burma-Shell stayed at Silcoorie T. E. during November and carried out trials with their products against Flushworm.

WEST BENGAL ADVISORY BRANCH

Mr. R. I. Macalpine—Senior Advisory Officer.

Mr. W. J. Grice—Advisory Officer, (designate for Darjeeling).

Mr. H. Mitra—Assistant Advisory Officer.

STAFF

The Senior Advisory Officer proceeded to Calcutta in October and remained in Calcutta till the end of the year. Mr. W. J. Grice took over his duties on the 25th October, and continued to act for him during his absence.

Mr. H. Mitra, Additional Advisory Officer joined the branch in April having completed his training at Tocklai. He left for his annual leave on the 15th November.

TOURING

146 member and 16 non member gardens were visited. These figures include gardens visited by Dr. D. N. Barua and Mr. S. K. Dutta during their tours in West Bengal.

MEETINGS

The Senior Advisory Officer attended the following meetings during the year. Annual General Meeting, Dooars Branch Indian Tea Association 26th January ; Annual General Meeting, Terai Planters Association on 23rd January ; Annual General Meeting, Darjeeling Branch Indian Tea Association on 16th March ; Annual General Meeting, Indian Tea Planters Association on 13th April. Mr. Macalpine, Mr. Grice and Mr. Mitra all attended the Tocklai Annual Conference on 12th to 14th November. Mr. Macalpine read two of the conference papers.

LECTURES AND DEMONSTRATIONS

The Senior Advisory Officer gave an informal talk at the Central Dooars Club on 31st May.

Mr. Grice gave a short lecture on "The Evaluation and Recording of Tasters Results" in the Vegetative Propagation courses held in May.

Mr. Grice attended a demonstration of Rotary Hoes held at the Jorhat Club in September.

COURSES

The Senior Advisory Officer attended and participated in the Annual Lecture Courses held at Tocklai from the 18th February to 8th March.

ADVISORY CORRESPONDENCE

434 letters and reports of an advisory nature were written during the year.

PUBLICATIONS

Mr. Grice published an article in "Two and a Bud" Vol. IV No. 3 entitled "*Albizzia molucanna*".

TECHNICAL REPORTS

The main feature of the 1957 season was the abnormal weather conditions. 4″—5″ of rainfall in the early part of the year and this encouraged the tea to flush; little or no rain fell from the middle of March to the end of May, and a severe drought was experienced in the whole of the Dooars and Terai. As a result of these drought conditions the weakened bushes succumbed to Red spider which was severe, and Red Rust was very noticeable on young tea throughout the Dooars and Terai.

The adverse effects of the drought coupled with heavy continuous rainfall and lack of sunshine during July and August resulted in considerable shortfalls in crop in many Estates (46 consecutive days of continual cloud and rain were recorded at the Branch Headquarters during July and August).

Albizzia procera. Continues to be killed by Orange Mite throughout the Dooars; in fact it is hard to find mature stands of this species which are not showing the effect of orange mite to a greater or lesser extent.

EXPERIMENTS

(In conjunction with S. K. Dutta, Agriculture Branch)

The following experiments, initiated in the year shown against each, were continued.

Dooars Experiments

NPK Manuring :

Kalchini T. E. (1954).— In one block three levels of nitrogen (0, 40 and 80 lbs. N/acre) and then 9 combinations of P. & K. at 0, 40 and 80 lbs. P_2O_5 and K_2O/acre randomly imposed to each whole block are being compared. In a second block sixteen combinations of 4 levels of P & K with 80 lbs. N/acre are being compared.

Ghatia T. E. (1957).— As above. During the year initial yields were recorded.

Nitrogen Manuring under shade :

Baradighi T. E. (1956).—This experiment is to test the effect of Nitrogen manuring at 0, 40, and 120 lbs. N/acre on yield of tea under *Albizzia odoratissima* shade. The following is a short report of this experiment to date.

Baradighi Nitrogen level experiment:—(*Expt. No. D. 6*).

This experiment was started in 1956 to see the effect of different levels of nitrogen on yield and crop distribution of tea. The tea is 41 year old Manipuri hybrid kind planted $4\frac{1}{2}'$ triangular. *Albizzia odoratissima* shade trees are planted 45′ apart and there are 6 shade trees in the border of each plot of 200 bushes. 1956 was the preliminary year. In 1957, the first experimental year the treatments failed to show any significant difference between them. The yields in maunds of made tea per acre of each treatment is given in table 1.

Table 1: Yields in maunds made tea/acre.

Level of Nitrogen per acre.	Yield (1957)
0 lb.	21·12
40 lb.	22·46
80 lb.	23·15
120 lb.	22·77

Times of Pruning:

Central Dooars T. E. (1955) Chuapara T. E. (1956) Bhogotpore T. E. (1957).— These experiments have been designed to find the effects on total crop and crop distribution by pruning at monthly intervals from 15th November to 15th February. The following are short reports of the Central Dooars and Chuapara experiments to date.

Central Dooars Tea Estate "Times of Pruning" Experiment: (Expt. No. D. 3).

This experiment was initiated in 1955 as the preliminary year and in the cold weather 1955-56, the following treatments were applied:

Table 2: Pruning Treatments.

Month of Prune	Nov.		Dec.		Jan.		Feb.	
How Pruned	Pruned	Skiffed	Pruned	Skiffed	Prun.	Skiff.	Prun.	Skiff.
Treatment No.	1	2	3	4	5	6	7	8

Each plot is pruned and skiffed alternately

In 1957 crop analysis has shown significant differences between the treatments as shown in table 3.

Table 3: Yields in pounds of green leaf per treatment.

Month Pruning	Nov.	Dec.	Jan.	Feb.	
Skiffing	2104	2219	2297	2083	8703
Pruning	2121	2208	2134	1866	8329
Total	4225	4427	4431	3949	

Sig. Diff. (P = .05) between individual figures = 216

The table shows that there is no significant difference between the skiffed treatments, but in case of treatments that were pruned, late pruning in February has significantly reduced the

crop. November, December and January pruning all have given significantly higher yields than February pruning but there are no significant differences between them. There is no significant difference between the overall effects of pruning and skiffing. It must be remembered, of course, that the above are only a single season's results.

Chuapara "Times of Pruning" Experiment: (Expt. No. D 5)

This experiment was initiated in 1956 as the preliminary year and in the cold weather 1956-57 the same treatments as in table 2 above were applied.

The analysis of 1957 crop yields have shown significant differences between the treatments. This is shown in table 4:

Table 4: Yield in pounds per treatment.

	November	December	January	February.
Pruning	1136	1135	1227	1159
Skiffing	1101	1049	1220	1118

Sig. Diff. (P = .05) = 118

Late pruning and late skiffing have not reduced the yield. On the contrary pruning in January and February have given significantly higher yield than December pruning. In case of skiffing also January skiffing has given significantly higher yield than November and December skiffing. There are, however, no significant differences in yield between January, February and November pruning and between November and December pruning. In case of skiffing, there is no significant difference between January and February skiffing and also between February, November and December skiffing. The highest yield has been obtained from both pruning and skiffing in the month of January, followed by February, November and December. In 1957, pruning or skiffing at different times has failed to effect any conspicuous changes in the periodic crop distribution such as between early season, rains and backend crop. It must again

be remembered that the above are the results of only a single season.

Pruning Cycles:

* **Baradighi T. E. (1955) and Chuapara T. E. (1956).—** These experiments are designed to discover the effect on total yield and crop distribution under annual and biennial pruning. In the biennially pruned plots in the unpruned year the effect of light, medium and deep skiffing are also being compared. The Baradighi experiment was started in 1955 with the same treatments as in the Chuapara experiment. Unfortunately it was found that the treatments were not correctly applied and it has now been decided to medium prune the plots in the cold weather of 1958 and to take preliminary yield figures in 1959. In the cold weather of 1959-60 the treatments will be applied by giving a top prune to all the plots. The previous treatments will remain unchanged. A short report of the Chuapara experiment to date is given herewith.

Chuapara Pruning Cycle Experiment: (*Expt. No. D. 2*)

This experiment was started in 1955. Preliminary yield figures were taken in 1955 following a top prune of all the treatment plots. The treatments are as follows:

(*a*) Annual prune.

(*b*) Biennial prune with light skiff in the unpruned years.

(*c*) Biennial prune with medium skiff in the unpruned years.

(*d*) Biennial prune with deep skiff in the unpruned years.

(*e*) Biennial prune with medium skiff when (*b*), (*c*) and (*d*) are pruned.

It is seen that the pruning system of treatment (*e*) is really the same as treatment (*c*) but when (*c*) is pruned (*e*) is skiffed and *vice-versa*. The reason for introducing treatment (*e*) is to eliminate differences in yield due to seasonal changes.

The summarised results of 1955, 1956 and 1957 are given in Table 5.

Table 5: Yield in maunds made tea/acre.

Treatment No.	1955		1956		1957		Total
	How Pruned	Yield	How Pruned	Yield	How Pruned	Yield	
(a)	Pruned	15.42	Pruned	13.18	Pruned	17.50	46.10
(b)	,,	14 96	Light skiff	13.71	,,	17.72	45.39
(c)	,,	15.56	Medium skiff	12.98	,,	17.38	45.92
(d)	,,	16 00	Deep skiff	13.27	,,	17.83	47.10
(e)	,,	15.32	Pruned	13 96	Medium skiffed	18.49	47.77
S. D. (P=.05)		...		Not sig.		Not sig.	

Both in 1956 and 1957 statistical analyses have not shown any significant difference between the treatments. This shows that so far the biennial prunes have failed to give any increased yield over the annual prune. There are, however, indications that light and medium skiffs may produce slightly higher yield in the early season's crop. A final assessment will of course depend on a comparison of total yields after the completion of several cycles.

* Misprinted in the 1956 Annual Report as triennially.

Cultivation :

Bhatpara T. E. (1957) and Chuapara T. E. (1957).— These are long term experiments for comparing the combination of different methods of cold weather and rains cultivation.

District Clonal Trial :

Nagrakata T. E. (1957) and Chuapara T. E. (1958).— These experiments were designed in conjunction with the Agricultural and Physico-Chemical Branch to compare the yielding capacity of 6 selected Tocklai clones in varying soil climate regions under different levels of nitrogen. A similar trial will be planted at Chuapara T. E. in 1958.

Shade Tree Experiments :

An experiment to compare the effect of different types of shade trees has been laid out in Nya Sylee Tea Estate.

Darjeeling Experiments

Nitrogen Manuring Experiments :

Happy Valley T. E. two experiments (1957) Singell T. E. (1957) and Selimbong T. E. (1957).— These experiments have different designs and layouts but their main object is common and that is to discover if applications of high levels of Nitrogen will increase the crop without reducing the flavour. Another object is to discover if divided doses of nitrogen will even out the crop distribution.

NPK Manuring :

Margaret's Hope T. E. (1940).— This experiments is for testing the effect of Nitrogen alone, N in combination with Phosphate and Potash and P & K alone. The levels are N 60, P 120, K 120, in combinations described and N 120 alone.

Rungneet T. E. (1954).— This experiment replicates in high elevation tea that established at Kalchini T. E. and Ghatia T. E. described above.

Times of Pruning Experiments :

Puttabong T. E. (1953).— Designed to discover the optimum time of pruning, in high elevation tea, so that the maximum amount of high quality teas are harvested. Pruning is done at monthly intervals.

Pruning cycle Experiments :

Nagri Farm T. E. (1951).— These experiments were to compare the effect of Annual and Biennial pruning on an Assam tea at a medium elevation.

Mim T. E. two experiments (1950) and Nagri Farm T. E. (1951). —These experiments were designed to test the effect on yields of biennial, triennial and quadrennial pruning cycles. Provision is made to compare the effects of skiffing as against unpruned in the triennial cycle, and also skiffing in the 1st year after pruning as against skiffing in the 2nd year after pruning. Reports of the two Mim experiments to date follow.

Mim Tea Estate Pruning Experiment: (Expt. No. Dj. 6)

The object of the experiment is to determine the optimum pruning system in relation to maximum crop production on a Northern aspect at elevation between 4,500 feet and above.

The experiment was started in 1950 with the following treatments.

1. *Biennial Prune*:
   1st Year—Prune.
   2nd Year—Unprune.

2. *Triennial Prune 'A'*:
   1st Year—Prune.
   2nd Year—Unprune.
   3rd Year—Unprune.

3. *Triennial Prune 'B'*:
   1st Year—Prune.
   2nd Year—Unprune.
   3rd Year—Light skiff.

4. *Triennial Prune 'C'*
   1st Year—Prune.
   2nd Year—Light skiff.
   3rd Year—Unprune.

5. *Quadrennial Prune.*
   1st Year—Prune.
   2nd Year—Unprune.
   3rd Year—Medium skiff.
   4th Year—Unprune.

During 1950-57 the biennial prune has completed four complete cycles and the three triennial prunes and the quadrennial prune only two complete cycles. The overall assessment of the effect of each treatment will be obtained by comparing the total yields of tea for each treatment after twelve years in which year all treatments will have returned to the pruning phase as in 1950. The results for the period of eight years from

1950-57 described here shows the yields in ozs. of green leaf per treatment.

Table 6: Yield in ozs. green leaf per treatment.

Treatment \ Year	1950	1951	1952	1953	1954	1955	1956	1957	Total
1. Biennial	407 P	1360 U. P.	1336 P	1274 U. P.	1227 P	1285 U. P.	527 P	642 U. P.	8058
2. Triennial 'A'	494 P	1442 U. P.	1382 U. P.	709 P	1572 U. P.	1350 U. P.	599 P	655 U. P.	8204
3. Triennial 'B'	398 P	1303 U. P.	1291 L. S.	602 P	1514 U. P.	1325 L. S.	626 P	620 U. P.	7679
4. Triennial 'C'	347 P	1400 L. S.	1310 U. P.	681 P	1676 L. S.	1358 U. P.	533 P	645 L. S.	7950
5. Quadrennial	546 P	1283 U. P.	1218 M. S.	1163 U. P.	1015 P	1253 U. P.	1415 M. S.	623 U. P.	8516
Sig. Diff. (P=.05)	...	Not sig.	Not sig	150	321	Not sig.	160	Not sig.	

P = Pruned ; U.P. = Unpruned ; L. S. = Light skiffed ; M S. = Medium skiffed.

Significant differences in yield have been obtained in 1953, 1954 and 1956. As a rule, any treatments that were either left unpruned or skiffed gave significantly higher yield than treatments that were pruned in the same year. But there was no significant difference between no prune, light skiff and medium skiff. This can be seen in 1951, 1955 and 1957. In each treatment cycle the skiffed/unpruned years generally gave higher yields than the pruned years. But it appears that seasonal changes might also have an influence on the crop yield of treatments. For example in 1957 the yields, irrespective of treatments, were much below the average of the other unpruned/skiffed years' yields. In the biennial pruning system, save in the first cycle, the drop in yield during pruned years was not much, whereas in the three triennial pruning systems pruning was followed by a big drop in yields. It will be seen that the trend of yields among the triennial prunes is quite similar and there has been

no significant difference between them in any year. However, the cumulative yield is highest in case of triennial 'A' which has two unpruned years in the cycle. This indicates that in the last two years of the triennial pruning cycle if the tea is neither pruned nor skiffed (except possibly a levelling off skiff) as in the triennial prune 'A' there is no loss in crop but may be a slight gain. The quadrennial prune has so far given the highest cumulative yield. It appears that this may be due to its having more unpruned/skiffed years than other pruning systems. However, as has been stated earlier no valid comparisons can be made just now.

Mim Tea Estate Pruning Experiment: (Expt. No. Dj. 7)

This experiment is an exact repetition of the experiment No. Dj 6.

This experiment was also started in 1950 and therefore the treatments have completed the same number of cycles as the above experiment, shows the yields in ozs. of green leaf per treatment. Table 7.

Table 7: Yield in ozs. green leaf per treatment.

Year / Treatment	1950	1951	1952	1953	1954	1955	1956	1957	Total
1. Biennial	455 P	1514 U.P.	1335 P	1480 U.P.	1095 P	1307 U.P.	617 P	738 U.P.	8541
2. Triennial 'A'	578 P	1260 U.P.	1433 U.P.	703 P	1494 U.P.	1431 U.P.	518 P	658 U.P.	8075
3. Triennial 'B'	498 P	1258 U.P.	1312 L.S.	472 P	1474 U.P.	1450 L.S.	544 P	738 U.P.	8016
4. Triennial 'C'	427 P	1265 L.S.	1330 U.P.	719 P	1320 L.S.	1395 U.P.	573 P	696 L. S.	7725
5. Quadrennial	449 P	1287 U.P.	1282 M.S.	1244 U.P.	1139 P	1400 U.P.	1460 M.S.	689 U.P.	8950
Sig. Diff. (P=·05)	...	Not sig.	Not sig.	335	224	Not sig.	126	Not sig.	

P = Pruned; U. P. = Unpruned; L. S. = Light skiffed; M. S. = Medium skiffed.

The results of this experiment are very similar to those obtained in the above experiment. That is skiffed/unpruned tea generally gave significantly higher yield than pruned tea as seen in 1953, 1954 and 1956. But there was no significant difference between light skiff, medium skiff and no prune. The trend of yield of different treatments of this experiment is in agreement with the trend described in the former experiment.

It will be appreciated that in both experiments a valid assessment of the treatment effects will be made by comparing total yields when all pruning cycles have returned to the same phase (after 12 years).

NAGRAKATA STATION REPORT

Visitors :

Mr. H. Ferguson, Director of Tocklai Experimental Station visited the branch in January and accompanied the Senior Advisory Officer on visits to several gardens and also to the Annual General Meeting of the Terai Planters Association, and the Annual General Meeting of the Dooars Branch Indian Tea Association.

Dr. D. N. Barua, Plant Physiologist visited the branch in June during his tour of the Dooars and Terai. The Senior Advisory Officer accompanied him to several gardens.

Mr. S. K. Dutta, Senior Agriculturist, visited the branch in September and was accompanied by the Senior Advisory Officer to several gardens.

Messrs. D. J. Gray and W. J. Grice, Advisory Officers visited the branch in May and accompanied the Senior Advisory Officer on visits to several gardens.

Mr. Charles Heureux of Office des Produits Agricles de Costermansville the Belgian Congo Government Tea Planters Administration visited the branch for a few days in May and accompanied the Senior Advisory Officer on visits to several gardens.

Prof. M. A. Bokuchava, Dr. V. R. Popov, Prof. M. S. C. Yakoklev and Mr. B. S. Oraevsky from Stalingrad visited the branch in June.

Administration :

During the drought the water supply to the Headquarters Bungalow and for nurseries and experiments at the Bungalow was inadequate in spite of the renewal of the pipe line. A storage reservoir of about 3,000 gallons capacity has been constructed and a pump is being put in. It is hoped that this will help to alleviate the position in the future.

The construction of quarters for the Meteorological Assistant has almost been completed.

INDIAN TEA ASSOCIATION (LONDON) CHEMICAL LABORATORY, BUTLER'S WHARF

E. A. H. ROBERTS—Research Manager

MRS. M. MYERS—Chemist.

STAFF

Dr. E. A. H. Roberts visited Tocklai from 22nd November until 11th December in order to discuss the closer integration of the research programmes of the Butler's Wharf Laboratory and the Biochemical Department.

At the end of this visit Dr. Roberts attended a meeting of the Scientific Department Sub-Committee in Calcutta and gave a short talk on the ways in which recently developed methods for the chemical analysis of made teas might be made use of in investigations into manufacture and in general advisory work.

RESEARCH

Theaflavins and thearubigins:

Methods, which will be described more fully in the appendix, have been developed for the isolation of theaflavin and theaflavin gallate in chemically pure form. Theaflavin itself has been crystallized.

It has also been established that theaflavin gallate is converted by the enzyme tannase into a mixture of theaflavin and gallic acid—thus confirming the view that one of the theaflavins is a gallic acid ester of the other.

Using these pure theaflavins, and thearubigin fractions previously isolated, it has proved possible to measure colour intensities of the individual theaflavins and thearubigins. As a result it is now possible to express the results of the analytical method for thearubigins and theaflavins as percentages of the weight of the tea taken. Results obtained by this method will be expressed in this way in the future. Unfortunately the factors calculated are only valid for the more elaborate spectrophotometer and still have to be expressed in arbitrary units.

In collaboration with Mr. R. F. Smith of Lyons' laboratories a large number of teas have been analysed during 1957. The table below records values obtained for the various grades of conventionally manufactured tea from one garden at intervals throughout the season.

Grade	Date	% Theaflavins	% Thearubigins
O. P. ...	18/6/57	0.75	7.8
	17/7/57	0.74	6.6
	22/8/57	0.60	6.2
	18/9/57	0.63	8.0
B. O. P. 1. ...	18/6/57	0.81	11.0
	17/7/57	0.68	8.7
	22/8/57	0.87	9.6
	18/9/57	0.77	10.0
B. O. P. ...	18/6/57	0.96	8.8
	17/7/57	0.73	8.4
	22/8/57	0.65	8.4
	18/9/57	0 65	8.2
O. F. ...	18 6/57	1.03	11.0
	17/7/57	0.75	9.2
	22/8/57	0.55	7.7
	18/9/57	0.66	9.8
B. P. ...	19/6/57	0.74	7.3
	17/7/57	0.56	5.6
	22/8/57	0.60	6.4
	18/9 57	0.45	6.1
P. F. ...	18/6/57	0.80	9.6
	17/7/57	0.66	8.0
	22/8/57	0.70	8.7
	18/9/57	0.52	7.2
Dust ...	18/6/57	0.86	10.6
	17/7/57	1.00	8.7
	22/8 57	0.93	8.9
	18/9/57	0.62	9.1
Dust I ...	18/6/57	0.81	9.2
	17/7/57	0.74	9.5
	22/8/57	0.74	9.2
	18/9/57	0.59	8.9

The grades B.O.P. 1, B.O.P. and O.F. have the reasonably high values for theaflavins and thearubigins which would be expected in conventional manufacture for grades manufactured largely from the finer portions of the shoots. The O.P. also originates from the finer portions of the shoots but as this grade also includes a considerable portion of the upper portion of the

stem (known to be low in total polyphenols), its relatively low content of polyphenolic oxidation products is not unexpected.

The B.P. grade originates largely from the coarser parts of the shoot, of relatively low polyphenol content; consequently the theaflavin and thearubigin contents associated with this grade are rather low. Values for P.F. are definitely higher due to this grade's smaller size which is associated with a greater extent of physical damage and quicker extraction in the cup. It will be noted that the average value for the P.F. is lower than for the O.F., which although of the same size originates from material of higher polyphenol content.

The effects of a greater extent of breaking up of the leaf, apparent from the comparison of B.P. with P.F., shows up even more clearly in the dusts which have quite high values for both theaflavins and thearubigins. These comparisons are illustrated in the table below.

Average contents of theaflavins and thearubigins in grades

Grade	% Theaflavins	% Thearubigins.
O.P.	0·68	7·2
B. O. P. 1	0·78	9·8
B. O. P.	0·75	8·5
O. F.	0·75	9·4
B. P.	0·59	6·3
P. F.	0·67	8.4
Dust	0·85	9·3
Dust I	0·72	9·2

Both theaflavins and thearubigins were at appreciably lower levels in the later monsoon months than during June.

Analyses were also carried out for a similar series of teas manufactured by a C.T.C. procedure. These results will not

be considered in such detail as the differences between grades were of less interest. In general the effect of C.T.C. treatment was to increase the amount of soluble matter extracted in the infusion by about 9%. The increase in theaflavins and thearubigin content however was much greater than this, as the following comparison between seasonal averages (of all grades combined) of conventionally and C.T.C. manufactured teas shows

	Theaflavins %	Thearubigins %
Conventional manufacture ...	0·72	8·5
C. T. C. manufacture	1·32	12·6

C.T.C. manufacture would appear to have effected a considerable increase in both theaflavins and thearubigins (far greater than the 9% increase in soluble matter in the taster's extract) and a notable increase in the ratio of theaflavins to thearubigins.

It might be argued that this comparison is not strictly valid as it involves comparisons between teas which were necessarily manufactured on different gardens. An experiment was carried out at Tocklai in which comparable samples of leaf underwent orthodox manufacture (two rolls) and C.T.C. manufacture. Analyses for bulk grades are given below.

	Theaflavins %	Thearubigins %
Conventional manufacture ...	1·02	12·7
C. T. C. manufacture ...	1·39	15·0

These figures confirm the deduction that C.T.C. treatment has resulted in higher values for both theaflavin and thearubigin contents.

Monthly average figures for C.T.C. manufactured teas are tabulated below.

	June	July	August	September	October.
Theaflavins ...	1·34	1·61	1·27	1·01	0·96
Thearubigins ...	13·9	14·4	13·1	10·9	10·8

Owing to poor climatic conditions in June the teas manufactured were probably not so good as might have been expected for this time of the year. Otherwise the teas show a marked deterioration in both theaflavin and thearubigin content as the season advances.

The chemical mechanism of tea-fermentation :

It was claimed in the previous Annual Report that the only polyphenols in tea-leaf to undergo oxidation during fermentation were 1-*epi*gallocatechin and 1-*epi*gallocatechin gallate. It has long been known that enzymic oxidation of these substances results in the formation of o-quinones, but the further chemical changes taking place have remained obscure. The enzymic oxidation of these two substances has now been studied in detail and as a result it has proved possible to suggest a mechanism of the chemical changes which lead to the formation of theaflavins and thearubigins. This mechanism is outlined in the more technical appendix which follows.

Chemical composition and taxonomy :

In his Annual Report for 1956 the Senior Botanist referred to joint work with the Biochemical Department and the Butler's Wharf laboratory on relations between chemical composition and taxonomy. It seems desirable to make some brief reference to this work which is still in progress.

The flavonol glycosides occurring in green leaf were listed in the 1956 Annual Report. Two of these, Kaempferol-3-rhamnodiglucoside and quercetin-3-rhamnodiglucoside (referred to in future as triglycosides) are characteristic of typical *C-*

Sinensis (*i.e.* the China variety), and are absent, or only present in very small quantities, in the other typical varieties. Triglycosides, however, are always found in leaf obtained from bushes which have originated from crosses of the China variety with other varieties.

A substance, at present referred to as IC, appears to be characteristic of the Southern form recognised by Wight (Nature, 179, 506, 1957). It is not found in the China or Assam varieties, or in crosses between these two varieties, but occurs in presumed crosses of the Southern form. Substance IC also occurs in the related species *C. taliensis* and *C. irrawadiensis*; the latter species also contains an uncharacterized polyphenol IR. Crosses of tea with either of these related species may contain IC and crosses with *C. irrawadiensis* may also contain IR.

The detection of triglycosides, or of IC or IR, in the leaf of cultivated tea-plants therefore gives some hint as to its botanical ancestry.

Investigations into the chemical nature of IC and IR are in progress but so far it has not been possible to devote much time to this. There is a possibility that IC and IR may be digalloyl and trigalloyl-esters of quinic acid respectively, which would relate them to theogallin which has now been established to be a monogalloyl-quinic acid.

PUBLICATIONS

The following scientific papers were published in 1957:

Roberts, E.A.H., Cartwright, R. A. and Oldschool, M., The Phenolic Substances of Manufactured Tea. I.—Fractionation and Paper Chromatography of Water Soluble Substances. *J. Sci. Fd. Agric.* 8, 72.

Roberts, E.A.H., Oxidation-Reduction Potentials in Tea Fermentation. *Chem. & Ind.*, p. 1354.

Roberts, E.A.H., Oxidative Condensations of Flavanols in Tea Fermentation. *Chem. & Ind.*, p. 1355.

Roberts, E.A.H., and Russell, G.R., Oxidation of Gallic Acid and Gallic Acid Esters to Aconitic Acid. *Chem. & Ind.*, p. 1598.

APPENDIX

The preparation of theaflavin and theaflavin gallate :

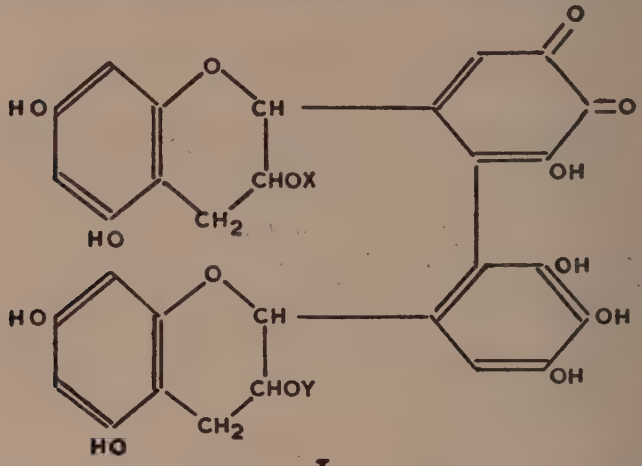
Theaflavin gallate — A strong extract of a tea was acidified with sulphuric acid and the resultant precipitate collected. This precipitate was suspended in water and extracted with ethylacetate. The extract was washed with 2.5% sodium bicarbonate and evaporated to dryness. The product was then factionated on a cellulose column, eluting with acetone-water (1 : 3). Three fractions were collected, the first of which represented the purest theaflavin gallate, free from theaflavin. This fraction was then further purified on a magnesolcelite column eluting with ether-ethyl acetate (5 : 1). The third and final fraction collected was usually almost pure theaflavin gallate. Analysis showed it to have the probable composition $C_{42}H_{32}O_{20}$, $2H_2O$ in agreement with the proposed molecular structure (IV). It has thirteen hydroxyl groups which can be readily methylated, and it yields gallic acid on hydrolysis.

Theaflavin — A strong tea infusion was inoculated with spores of *Aspergillus niger* and left until the surface was covered with a thick mat of the sporulating fungus. The infusion was filtered free from the fungus, extracted with ethyl acetate, and the extract washed with 2.5% sodium bicarbonate. Subsequent handling followed the same course as the preparation of theaflavin gallate except that the third fraction was collected from the cellulose column on elution with aqueous acetone. This third fraction was free from theaflavin gallate. The third fraction from the magnesol-celite column was usually pure theaflavin with molecular composition $C_{35}H_{28}O_{16}$,$4H_2O$ agreeing with the proposed structure (III) and having ten readily methylated hydroxyl groups.

The mechanism of tea-fermentation :

Both l-*epi*gallocatechin and l-*epi*gallocatechin gallate first undergo enzymic oxidation to the corresponding o-quinones.

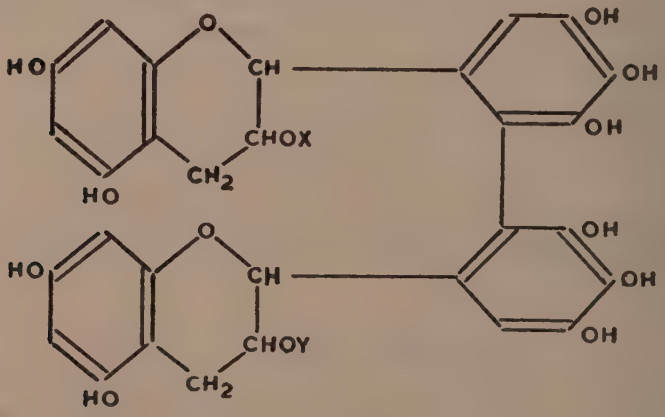
The resultant o.-quinones are then believed to dimerize with the formation of unstable intermediates of the structure (I).



I

Three different dimers could be formed with X=Y=H, X=Y=galloyl, and X=H, Y=galloyl, by the oxidative condensation of two molecules of l-*epig*allocatechin, two molecules of l-*epig*allocatechin gallate and of one molecule of l-*epig*allocatechin with one of l-*epig*allocatechin gallate.

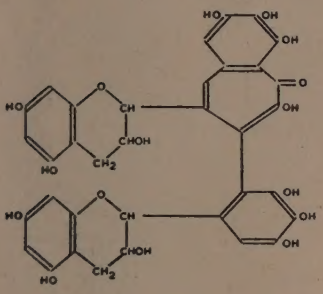
Reduction of these three intermediates would result in the formation of bisflavanols of the structure (II).



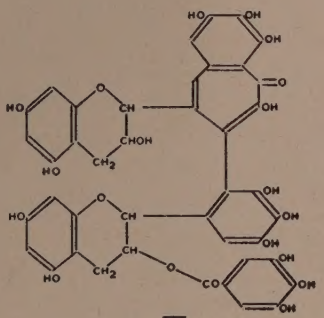
II

Three such bisflavanols would be produced, corresponding with the three substances A, B and C detected in black tea extracts. Substance A is believed to be the digalloyl derivative (X = Y = galloyl), substance B the monogalloyl derivative (X = H, Y = galloyl), and substance C has X = Y = H.

Oxidation of the intermediates, provided that the intermediate has at least one galloyl group, yields the theaflavins. Theaflavin (III) originates as a result of the oxidation of the monogalloyl intermediate and theaflavin gallate (IV) by the oxidation of the intermediate with two galloyl groups.



III



IV

The theaflavins can undergo further "coupled" oxidation, with l-*epi*catechin, d-catechin or l-*epi*catechin gallate as carriers. It is considered probable that the oxidation products formed in this manner are thearubigins. This does not exclude the possibility that thearubigins may be formed by other mechanisms.

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